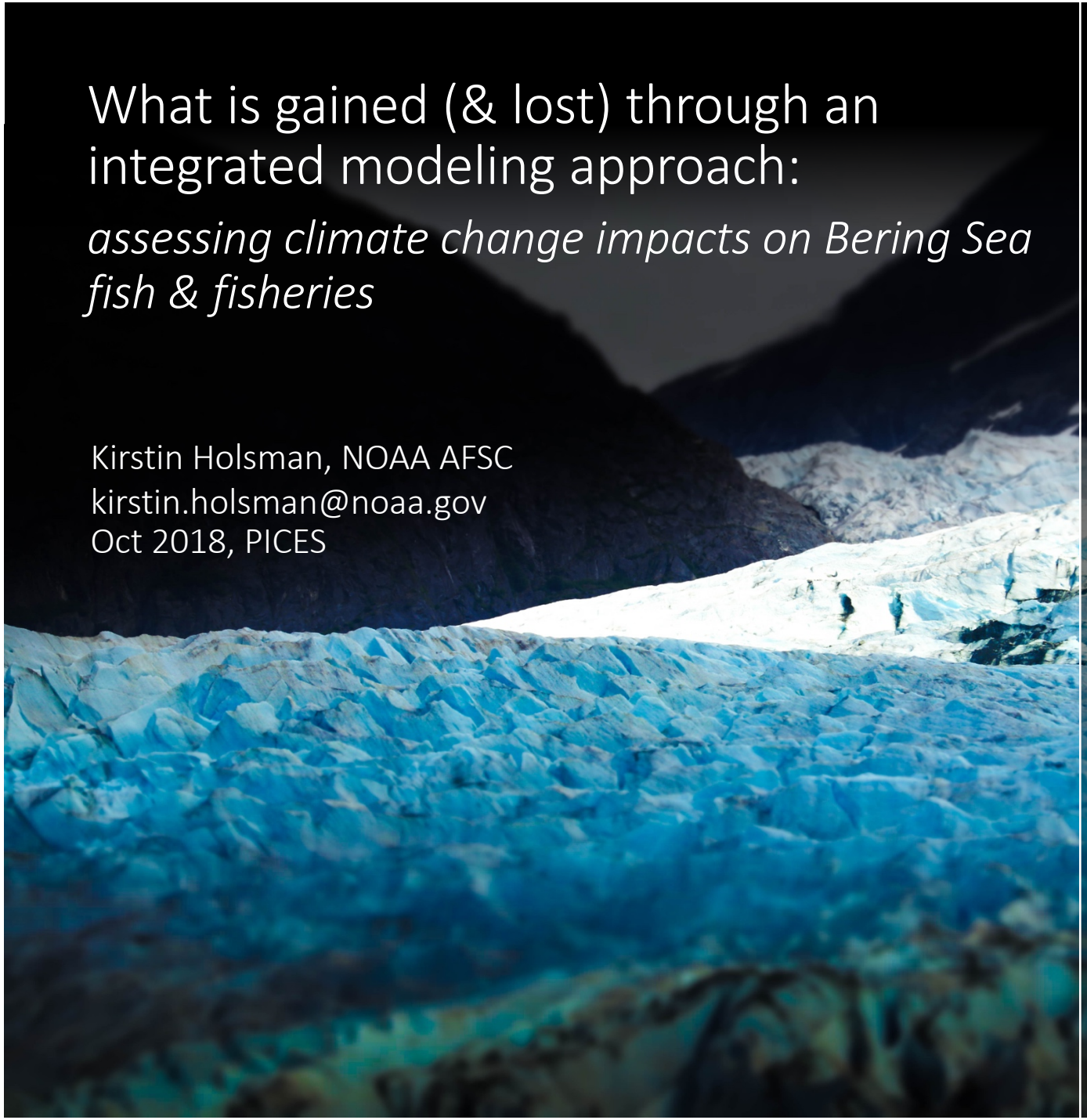
What is gained (& lost) through an integrated modeling approach:

assessing climate change impacts on Bering Sea fish & fisheries

Kirstin Holsman, NOAA AFSC
kirstin.holsman@noaa.gov
Oct 2018, PICES

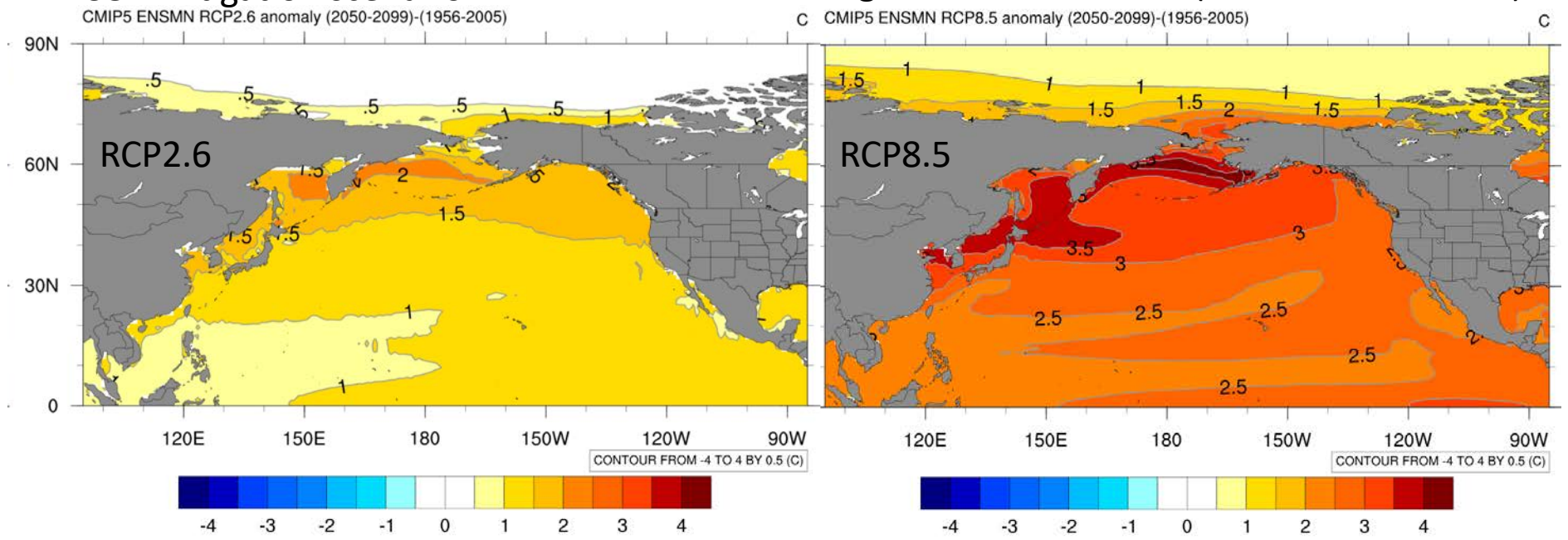


Anne Hollowed, NOAA
Alan Haynie, NOAA
Kerim Aydin, NOAA
Al Hermann, UW
Wei Cheng, UW
Amanda Faig, UW
Jim Ianelli, NOAA
Stephen Kasperski, NOAA
Kelly Kearny, UW
André Punt, UW
Jonathan Reum, UW
Paul Spencer, NOAA
William Stockhausen, NOAA
Cody Szuwalski, NOAA
Thomas Wilderbuer, NOAA
Trond Kristiansen, NOR

CMIP5 ENSMN Annual SST anomaly (°C)
(2050 to 2099) - (1956 to 2005)

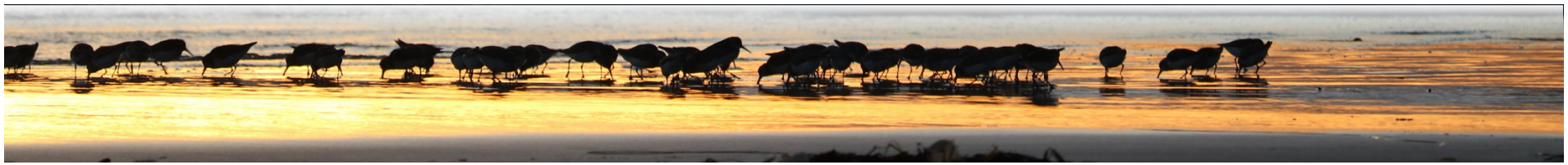
CO2 mitigation scenario

High baseline scenario ("Business as usual")

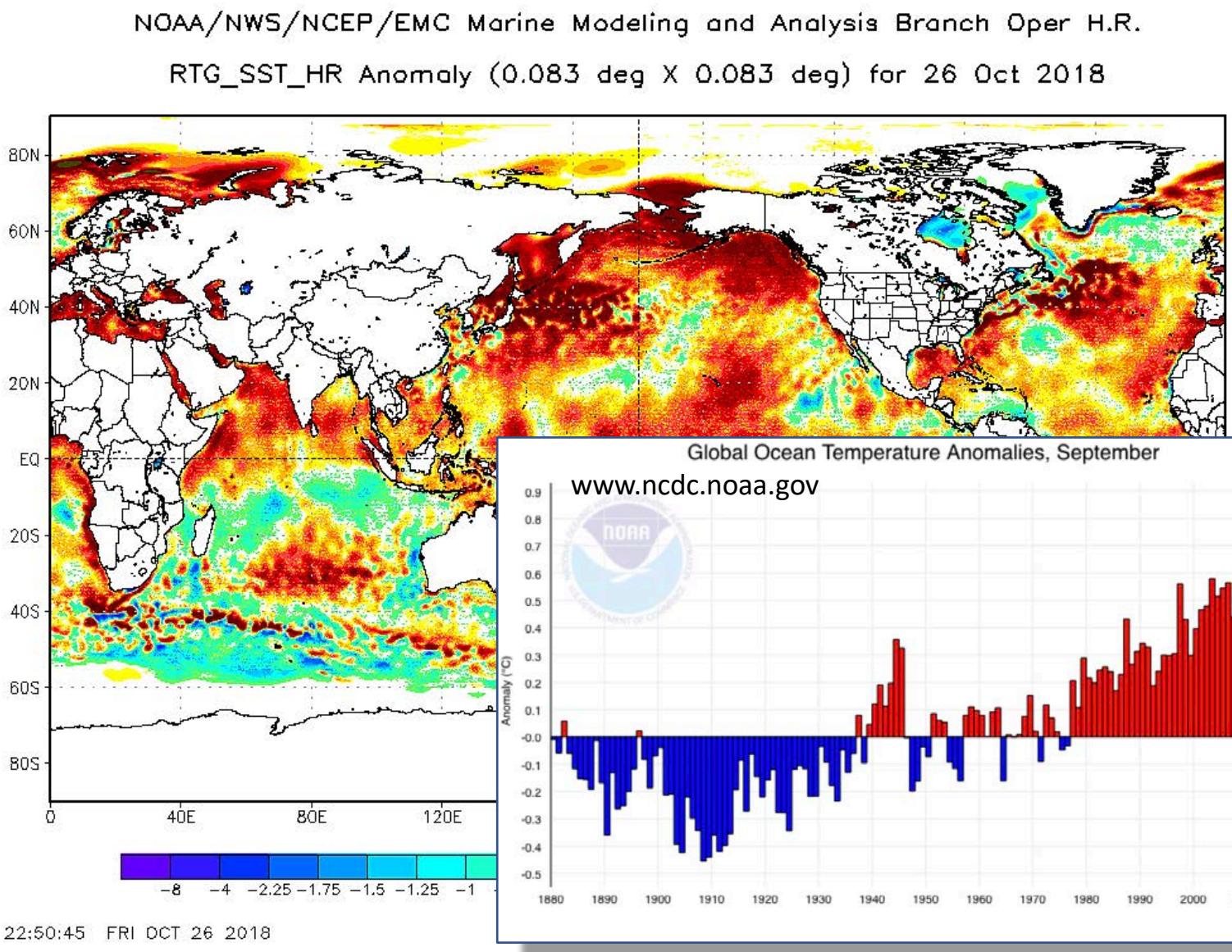


Projection data from CMIP5 (Taylor et al., 2012) avail. at: www.esrl.noaa.gov/psd/ipcc/ocn

Modified from Fig. 6.2 Holsman et al. 2018 [in] Barange et al. (Eds.) 2018. Impacts of climate change on fisheries and aquaculture. TP 627.



Anomaly from 1961-1990 climatology, 1 degree, weekly resolution



http://polar.ncep.noaa.gov/sst/rtg_high_res

nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-018-03732-9 OPEN

Longer and more frequent marine heatwaves over the past century

Eric C.J. Oliver[1,2,3], Markus G. Donat[4,5], Michael T. Burrows[6], Pippa J. Moore[7], Dan A. Smale[8,9], Lisa V. Alexander[4,5], Jessica A. Benthuysen[10], Ming Feng[11], Alex Sen Gupta[4,5], Alistair J. Hobday[12], Neil J. Holbrook[2,13], Sarah E. Perkins-Kirkpatrick[4,5], Hillary A. Scannell[14,15], Sandra C. Straub[9] & Thomas Wernberg[9]

Progress in Oceanography 141 (2016) 227–238

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journal homepage: www.elsevier.com/locate/pocean

A hierarchical approach to defining marine heatwaves

Alistair J. Hobday[a,*], Lisa V. Alexander[b,c], Sarah E. Perkins[b,c], Dan A. Smale[d,e], Sandra C. Straub[e], Eric C.J. Oliver[b,f], Jessica A. Benthuysen[g], Michael T. Burrows[h], Markus G. Donat[b,c], Ming Feng[i], Neil J. Holbrook[b,f], Pippa J. Moore[j], Hillary A. Scannell[k,l], Alex Sen Gupta[b,c], Thomas Wernberg[e]

[a] CSIRO Oceans and Atmosphere, Hobart, Tasmania 7000, Australia
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[e] UWA Oceans Institute and School of Plant Biology, The University of Western Australia, Crawley, 6009 Western Australia, Australia
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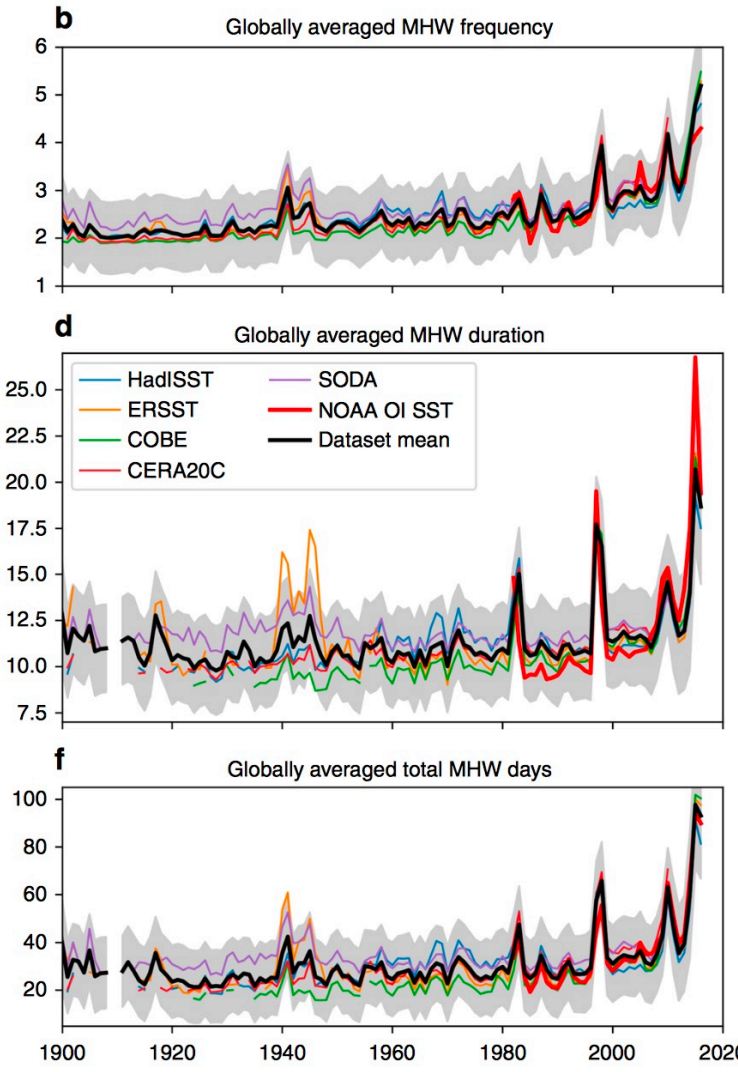
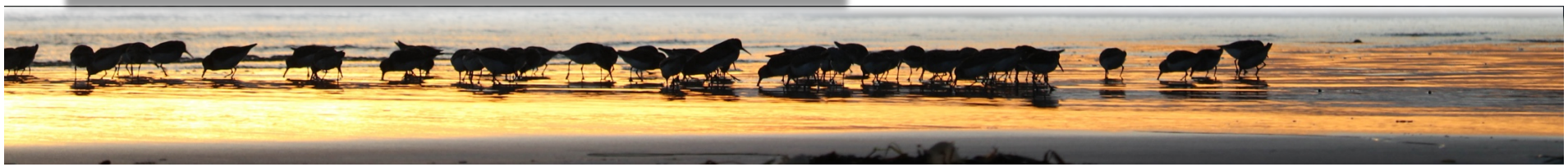
[g] Australian Institute of Marine Science, Townsville, Queensland, Australia
[h] Department of Ecology, Scottish Association for Marine Science, Scottish Marine Institute, Oban, Argyll PA37 1QA, Scotland, UK
[i] CSIRO Oceans and Atmosphere, Perth, Western Australia, Australia
[j] Institute of Biological, Environmental and Rural Sciences, Aberystwyth University, Aberystwyth SY23 3DA, UK
[k] School of Oceanography, University of Washington, Seattle, WA, USA
[l] NOAA/Pacific Marine Environmental Laboratory, Seattle, WA, USA



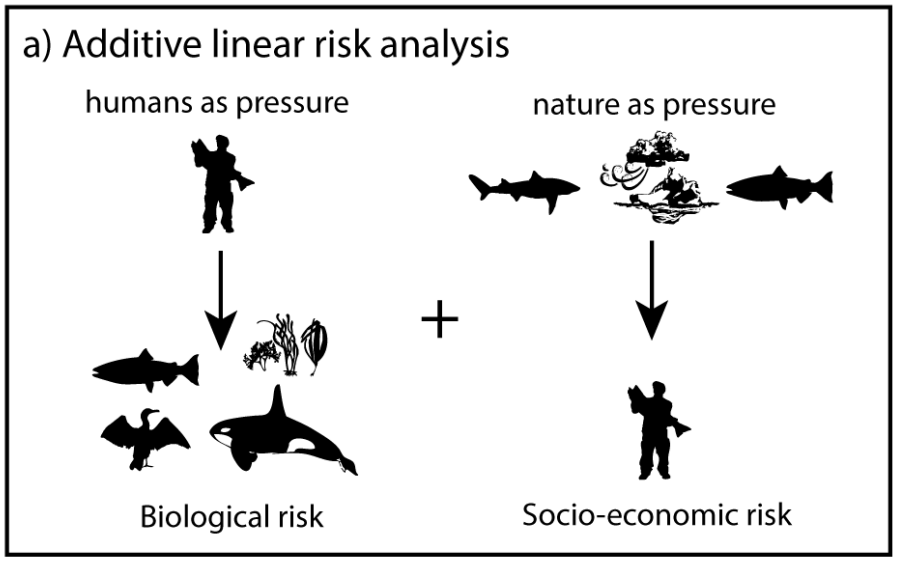


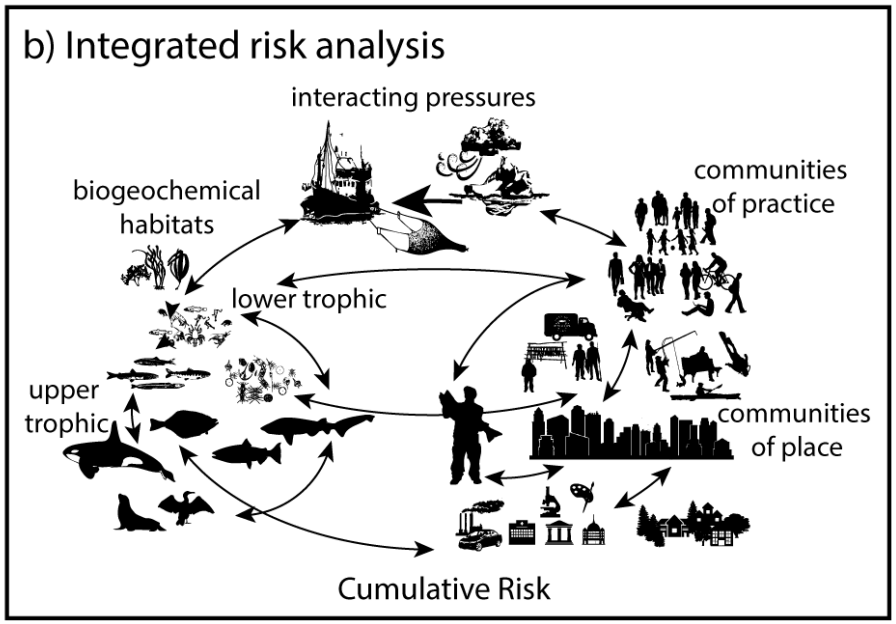
Inaction is maladaption

- Manuel Barange

What is an integrated approach?

Integrated Approach





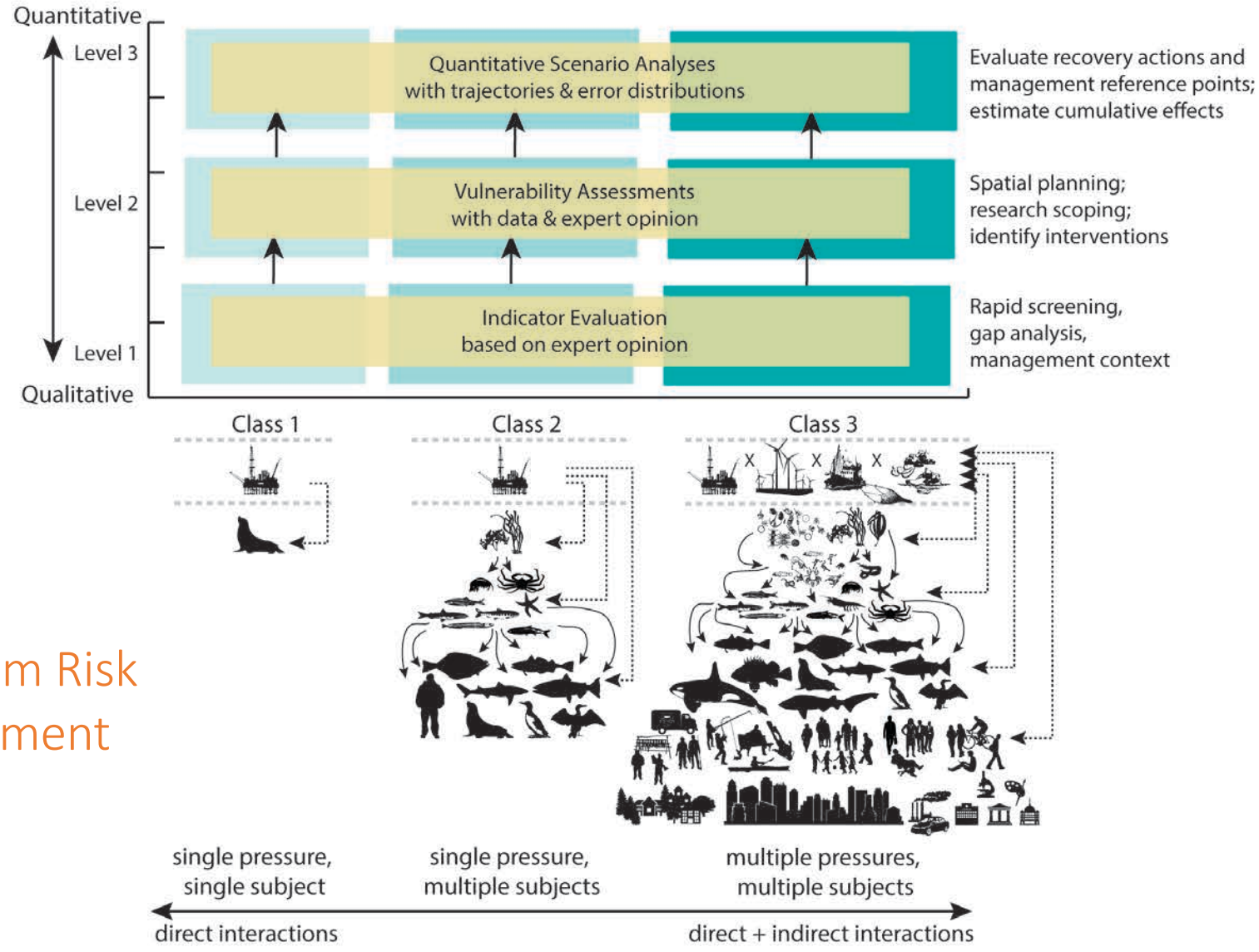
"Risk integrates the likelihood of exposure to a hazard and the magnitude of its impact"

"Impacts can have beneficial or adverse outcomes"

-IPCC 2018 (SR15)

Holsman et. al 2017. An ecosystem-based approach to marine risk assessment. Ecosystem Health and Sustainability 3(1):e01256. 10.1002/ehs2.1256

Ecosystem Risk Assessment



Holsman et. al 2017. An ecosystem-based approach to marine risk assessment. Ecosystem Health and Sustainability 3(1):e01256. 10.1002/ehs2.1256

Sustainable tools ≠ climate change tools

PNAS

Income diversification and risk for fishermen

Stephen Kasperski[a,1] and Daniel S. Holland[b,1]

[a]Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98115; and [b]Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA 98112

Edited by Stephen Polasky, University of Minnesota, St. Paul, MN, and approved December 12, 2012 (received for review July 17, 2012)

Catches and prices from many fisheries exhibit high interannual variability, leading to variability in the income derived by fishery participants. The economic risk posed by this may be mitigated in some cases if individuals participate in several different fisheries, particularly if revenues from those fisheries are uncorrelated or

to them beyond adopting less-risky farming strategies. They often have access to subsidized crop insurance, price supports, and futures markets (19–22), none of which are available to fishermen. Extending crop insurance-like programs to commercial fisheries harvesters has been suggested (23–26), but a feasibility

Fishers don't always follow the fish

ICES Journal of Marine Science Advance Access published June 8, 2012

ICES Journal of Marine Science

ICES CIEM International Council for the Exploration of the Sea / Conseil International pour l'Exploration de la Mer

ICES Journal of Marine Science; doi:10.1093/icesjms/fss097

The effect of decreasing seasonal sea-ice cover on the winter Bering Sea pollock fishery

Lisa Pfeiffer and Alan C. Haynie*

REFM Division, Alaska Fisheries Science Center, Economics and Social Sciences Research Program, NOAA National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA 98115, USA

**Corresponding author: tel: +1 206 5264253; fax +1 206 5266723; e-mail: alan.haynie@noaa.gov.*

Pfeiffer, L., and Haynie, A. C. The effect of decreasing seasonal sea-ice cover on the winter Bering Sea pollock fishery. – ICES Journal of Marine Science, doi:10.1093/icesjms/fss097.

Received 15 September 2011; accepted 8 April 2012.

A BERING SEA EXAMPLE

The Alaska Climate-change Integrated Modeling Project (ACLIM)

The ACLIM team


Anne Hollowed


Kirstin Holsman


Alan Haynie


Kerim Aydin


Albert Hermann


Wei Cheng


Stephen Kasperski


Jim Ianelli


Andre Punt


Andy Whitehouse


Jonathan Reum


Amanda Faig

Christine Stawitz

Kelly Kearney


Paul Spencer


Michael Dalton


Darren Pilcher


Tom Wilderbuer


Cody Szuwalski

William Stockhausen

Ingrid Spies

Improve management **foresight** in a changing climate

Protect **adaptive capacity** in fish and fisheries

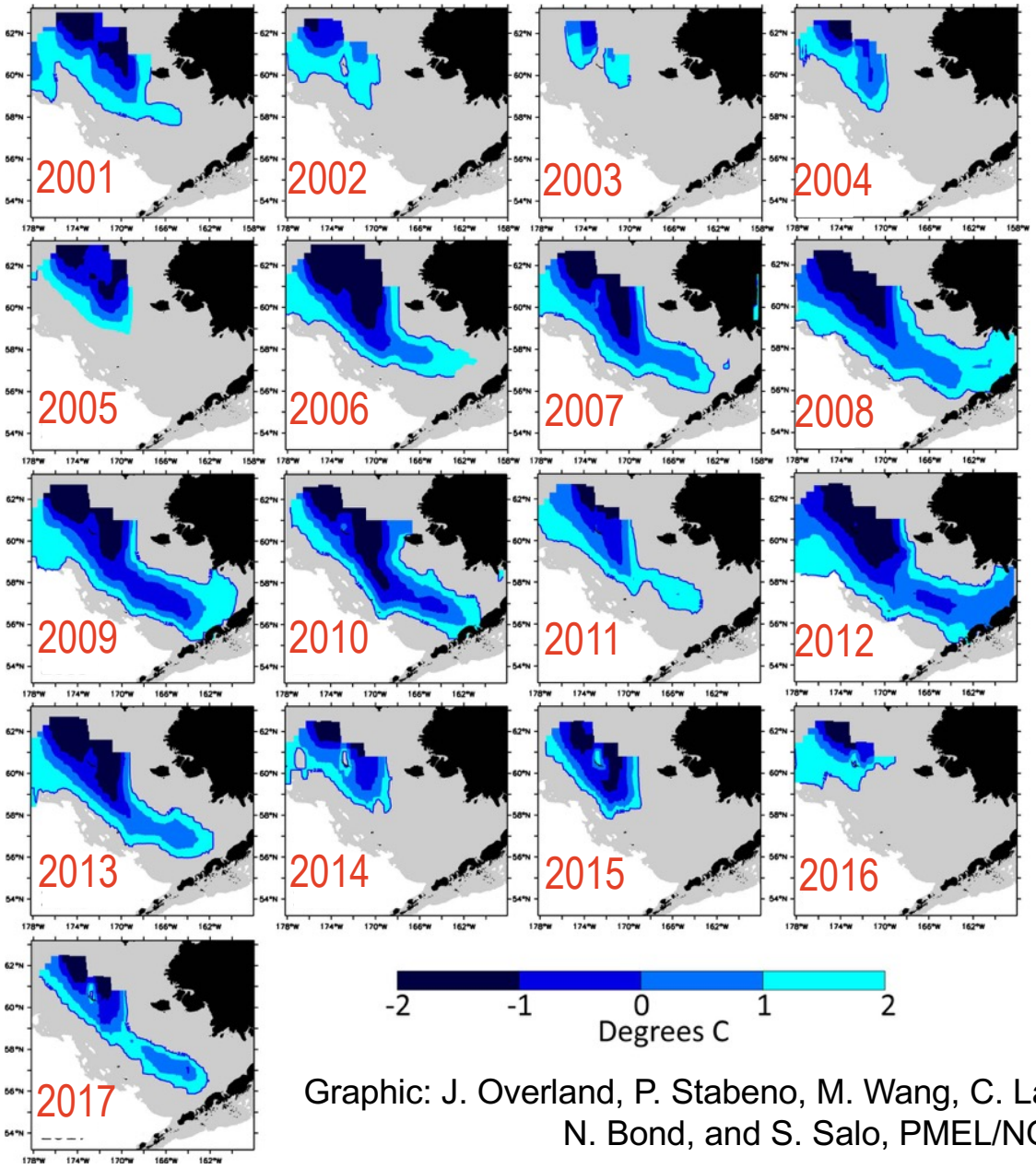
Project changes in Bering Sea ocean conditions and fish populations

Physical, biological, & socioeconomic change; now - 2100

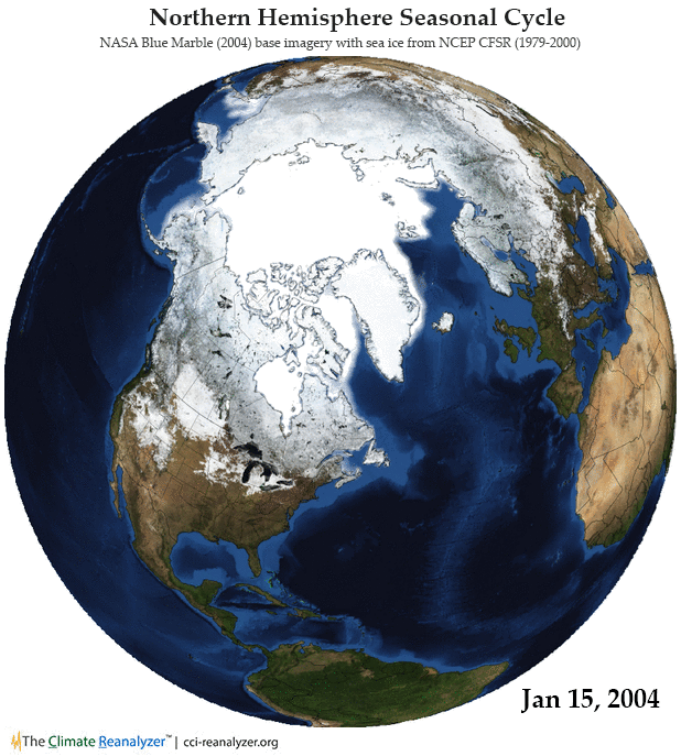
Evaluate how management can adapt to minimize negative impacts of future changes

gradual change & sudden shocks; test existing & new tools; estimate risk

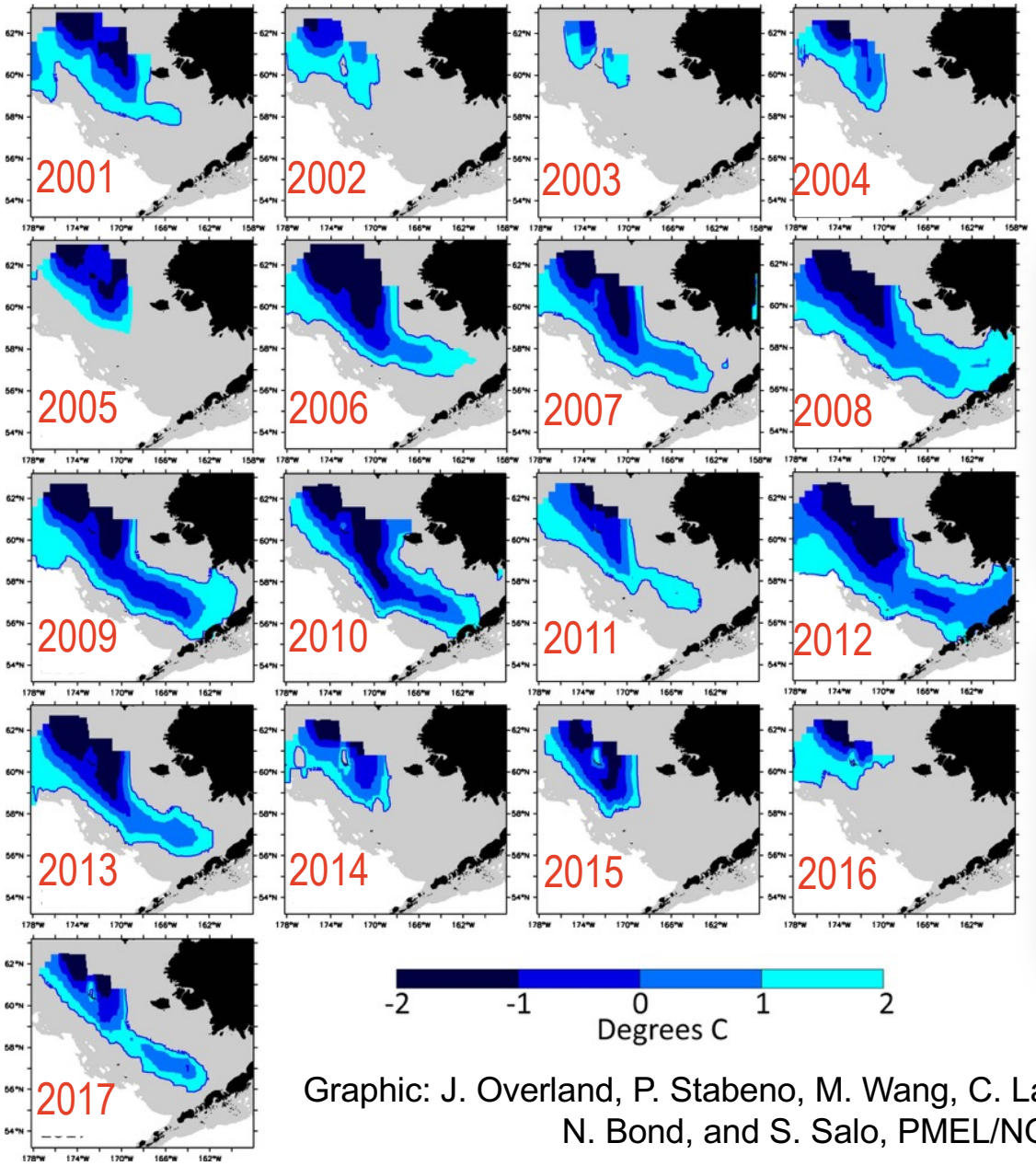
Bering Sea "Cold Pool" 2001-2017



Graphic: J. Overland, P. Stabeno, M. Wang, C. Ladd, N. Bond, and S. Salo, PMEL/NOAA



Bering Sea “Cold Pool” 2001-2017



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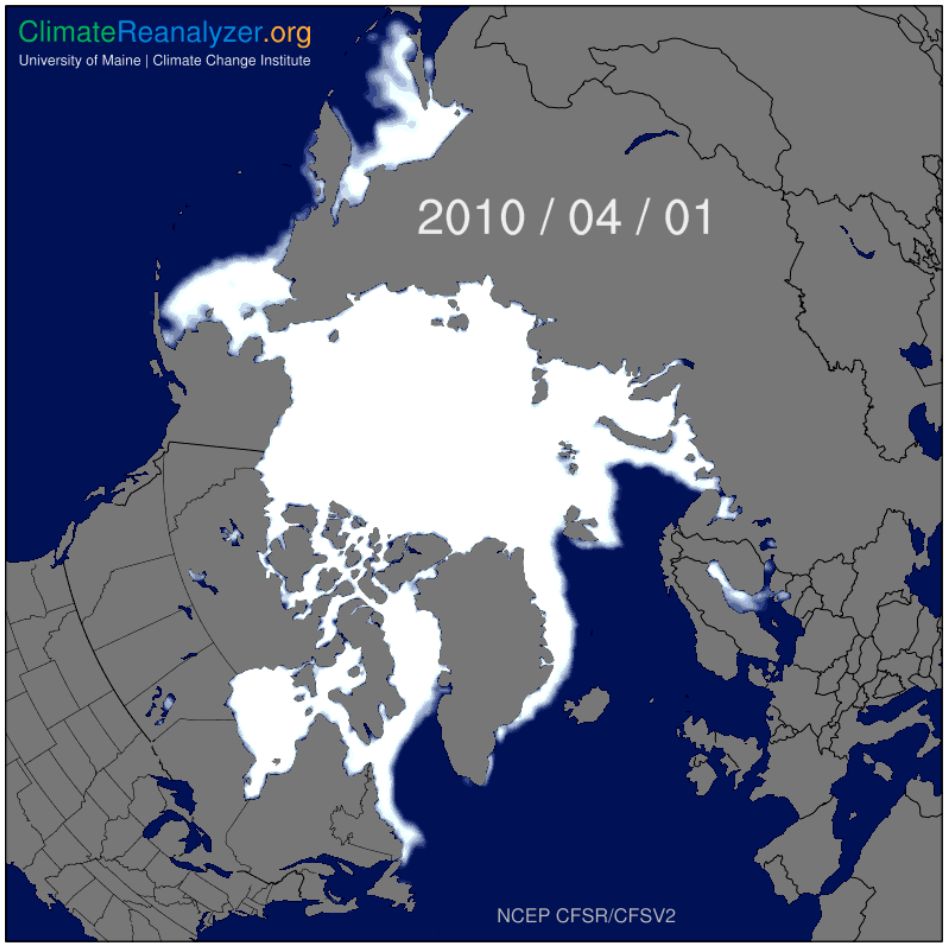
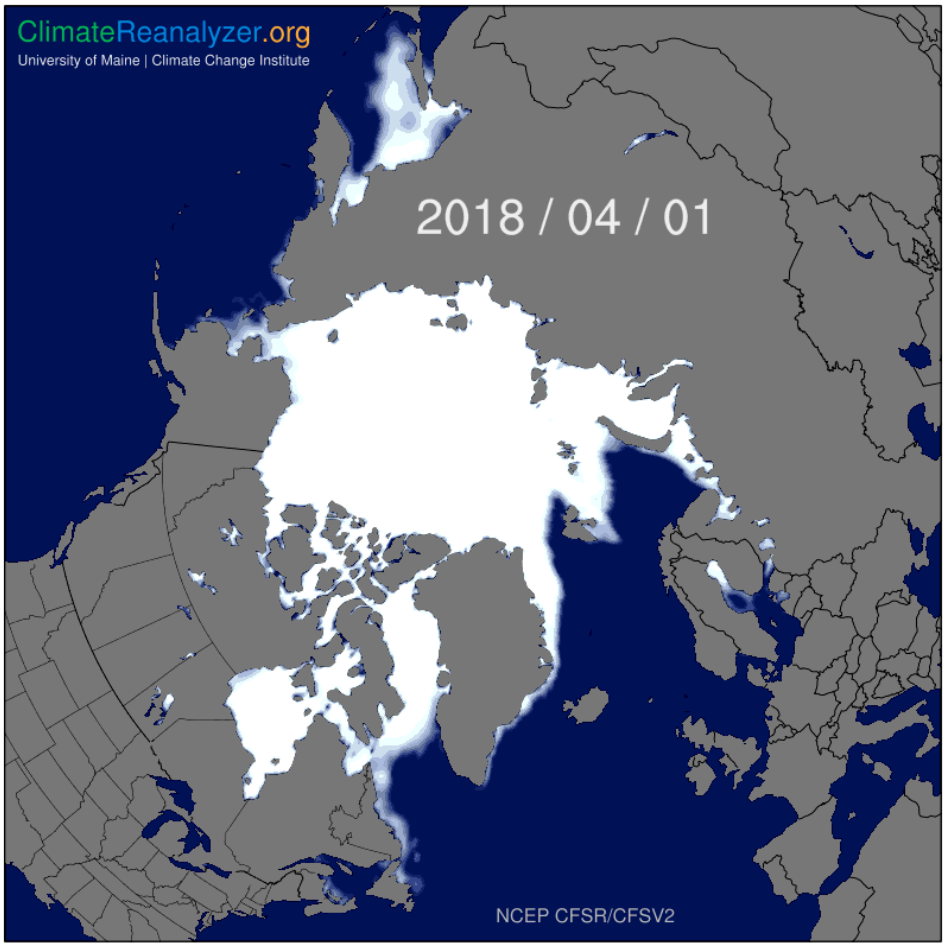
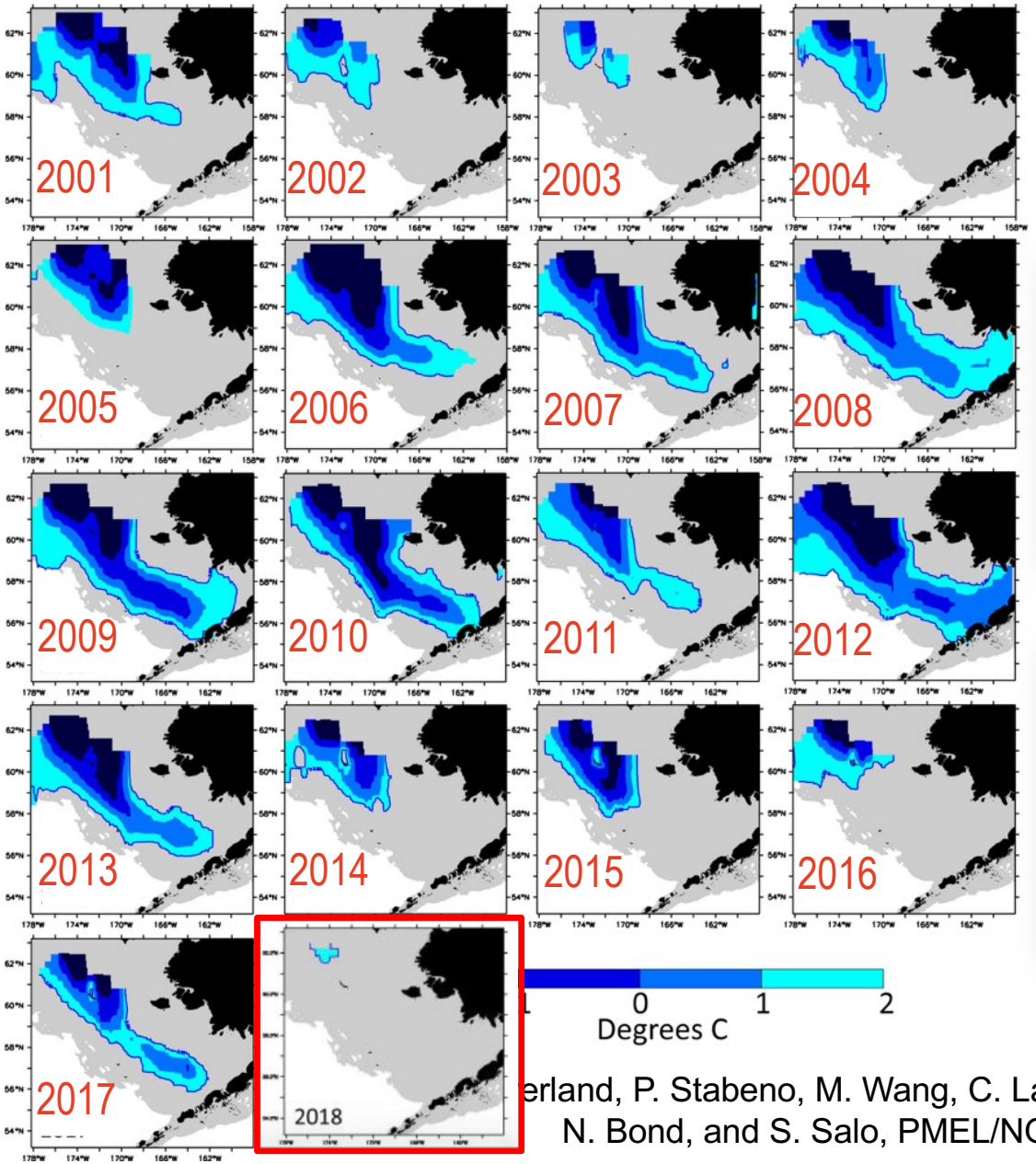




climatereanalyzer.org

Bering Sea “Cold Pool” 2001-2017



erland, P. Stabeno, M. Wang, C. Ladd,
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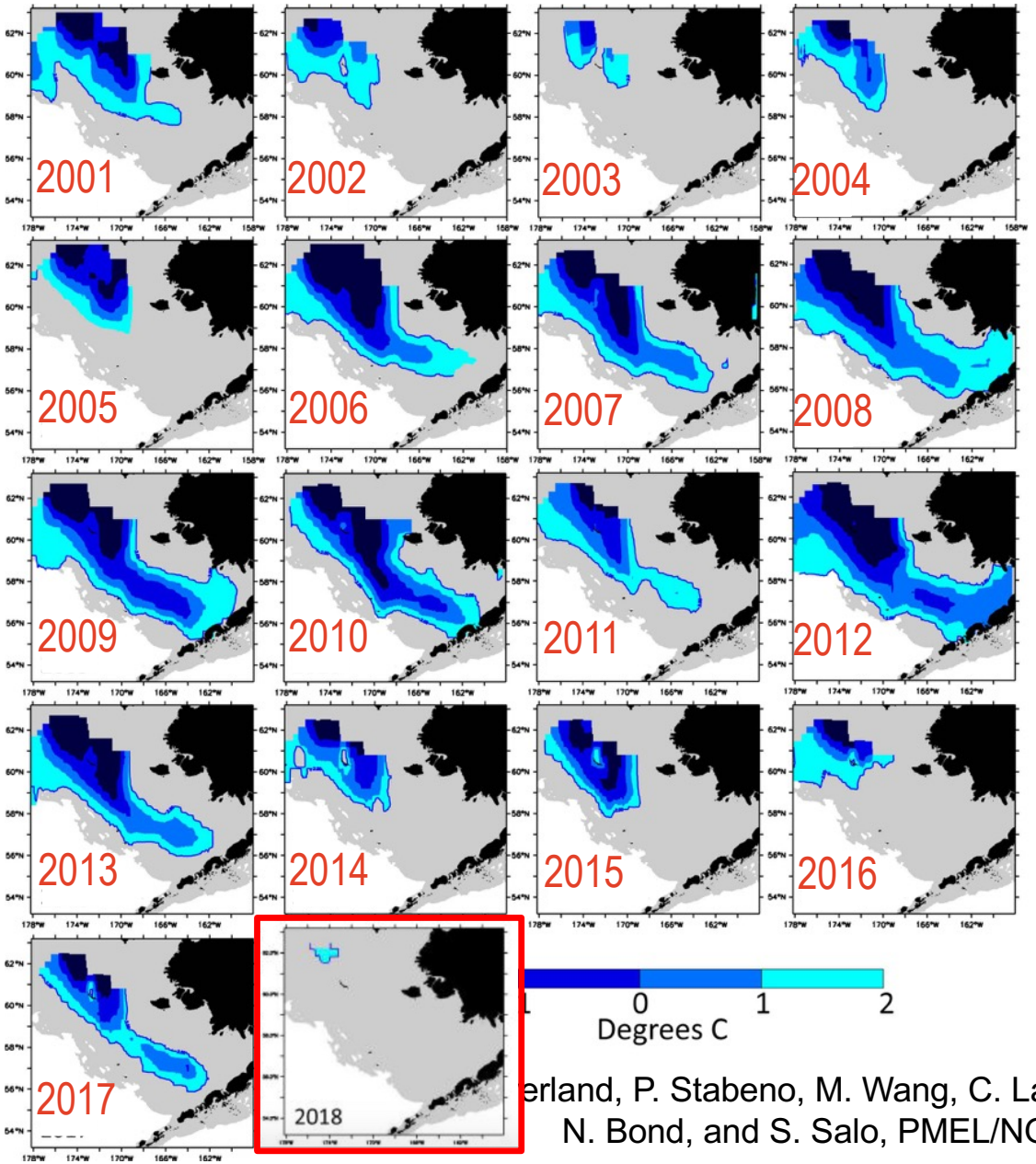
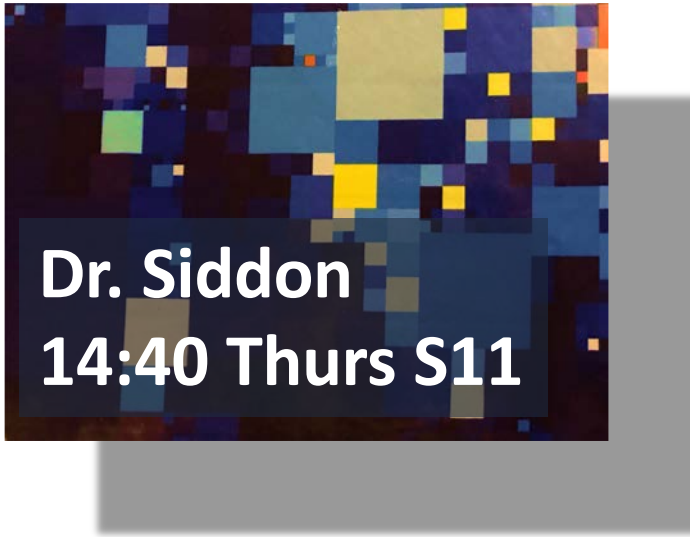
Bering Sea “Cold Pool” 2001-2017





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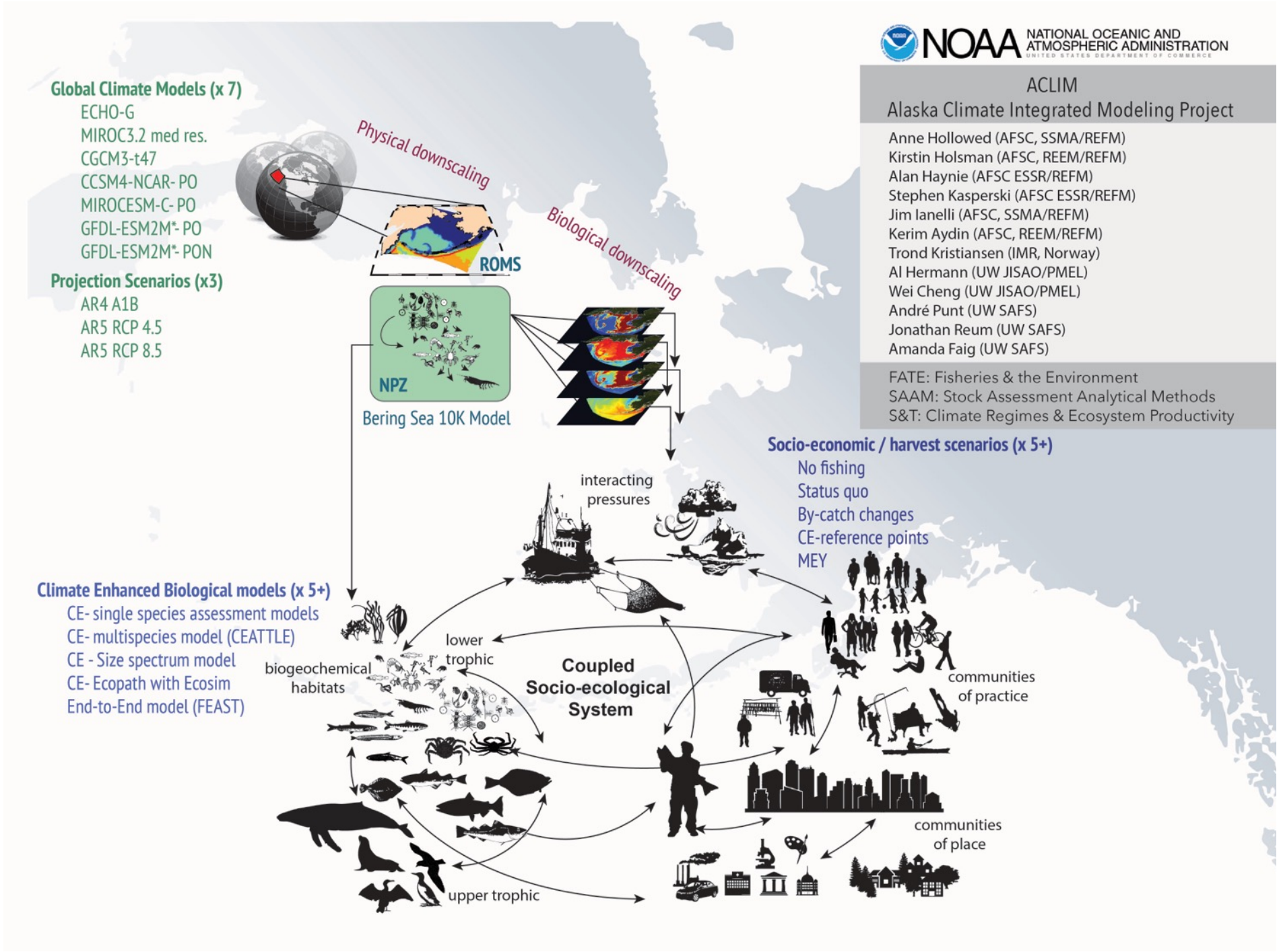
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ACLIM
Alaska Climate Integrated Modeling Project
Anne Hollowed (AFSC, SSMA/REFM)
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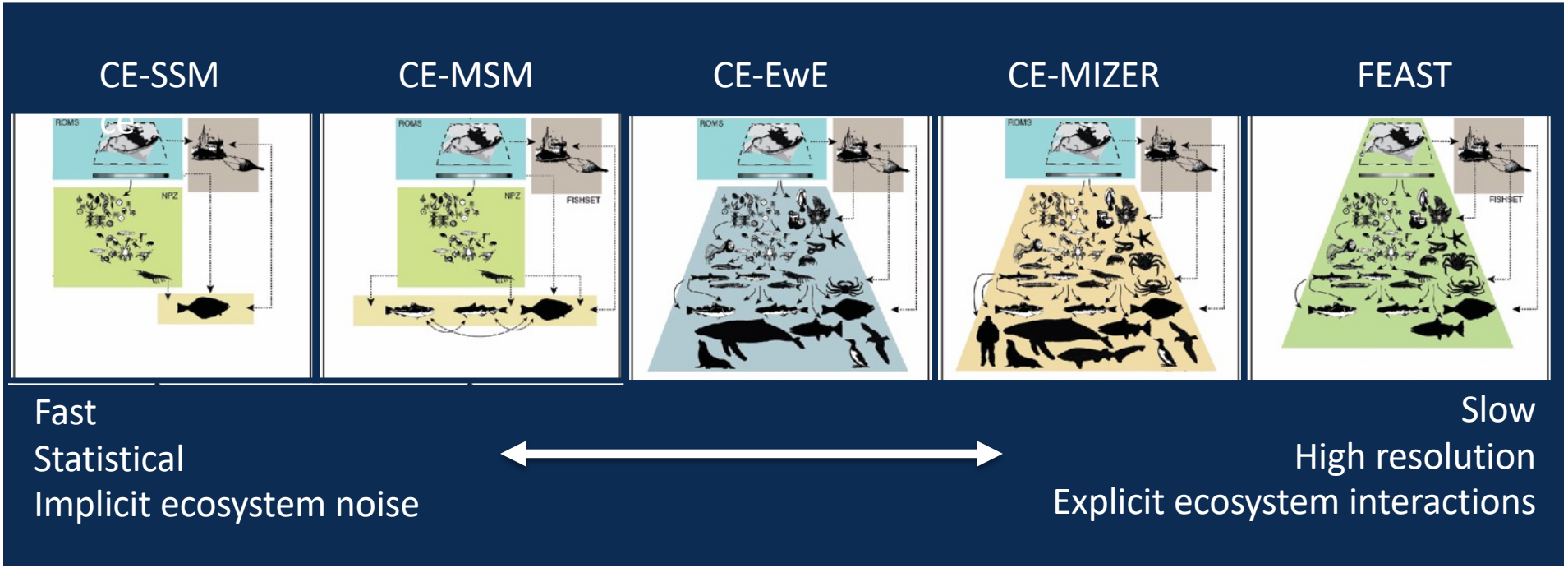
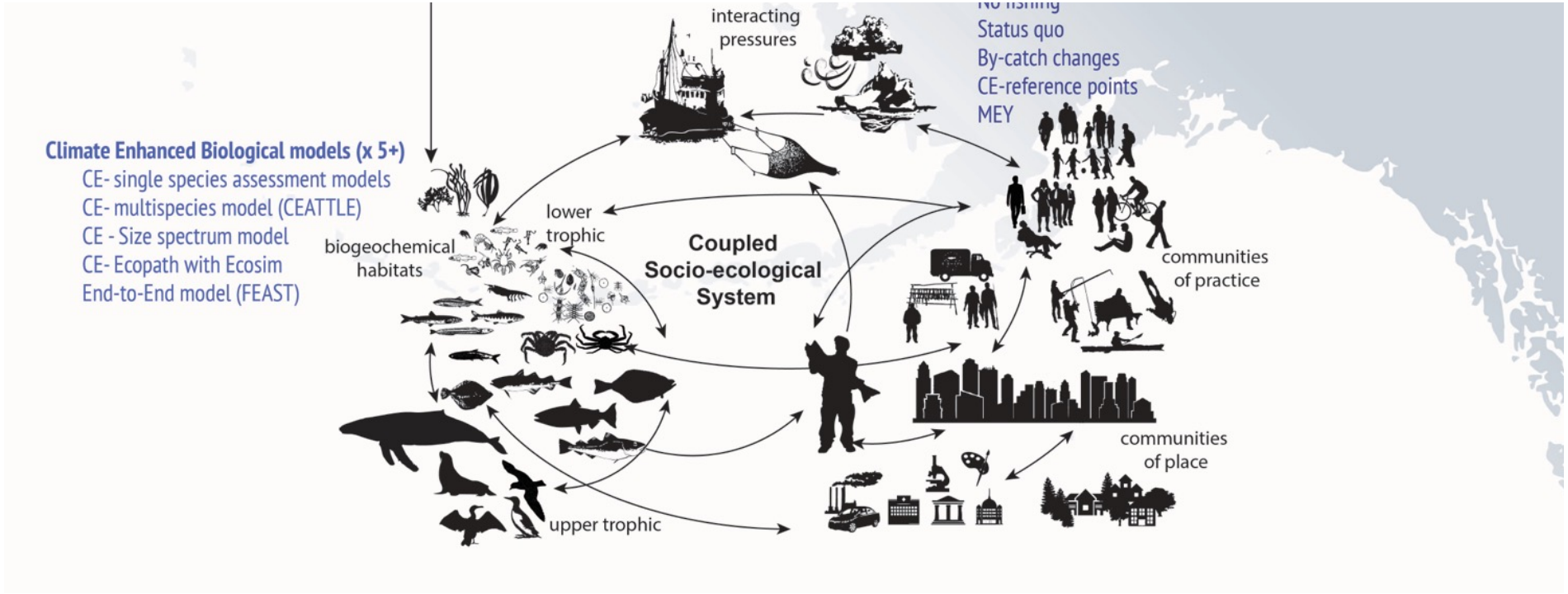
Al Hermann (UW JISAO/PMEL)
Wei Cheng (UW JISAO/PMEL)
André Punt (UW SAFS)
Jonathan Reum (UW SAFS)
Amanda Faig (UW SAFS)
FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity
Global Climate Models (x 7)
ECHO-G
MIROC3.2 med res.
CGCM3-t47
CCSM4-NCAR- PO
MIROCESM-C- PO
GFDL-ESM2M*- PO
GFDL-ESM2M*- PON
Projection Scenarios (x3)
AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5
Physical downscaling
ROMS
Biological downscaling
NPZ
Bering Sea 10K Model
Socio-economic / harvest scenarios (x 5+)
No fishing
Status quo
By-catch changes
CE-reference points
MEY
interacting pressures
Climate Enhanced Biological models (x 5+)
CE- single species assessment models
CE- multispecies model (CEATTLE)
CE - Size spectrum model
CE- Ecopath with Ecosim
End-to-End model (FEAST)
lower trophic
biogeochemical habitats
Coupled Socio-ecological System
communities of practice
communities of place
upper trophic


CE-SSM
CE-MSM
CE-EwE
CE-MIZER
FEAST
ROMS
NPZ
FISHSET
Fast
Statistical
Implicit ecosystem noise
Slow
High resolution
Explicit ecosystem interactions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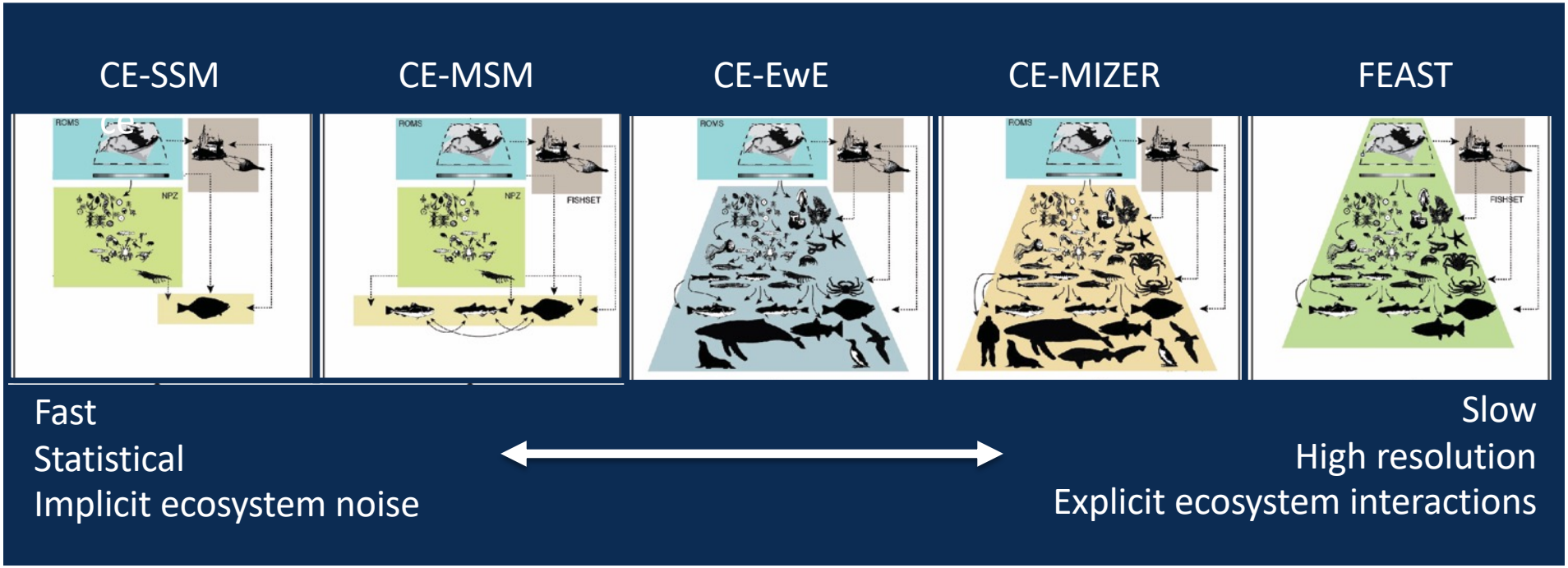
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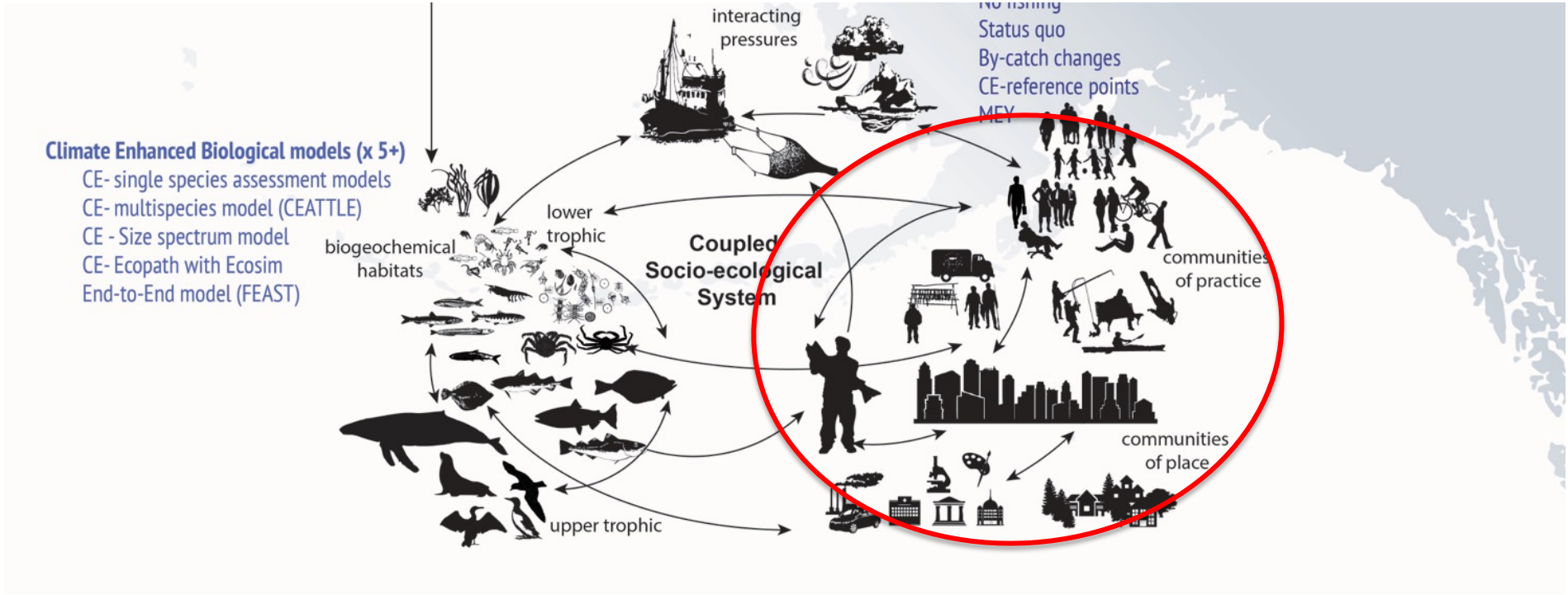
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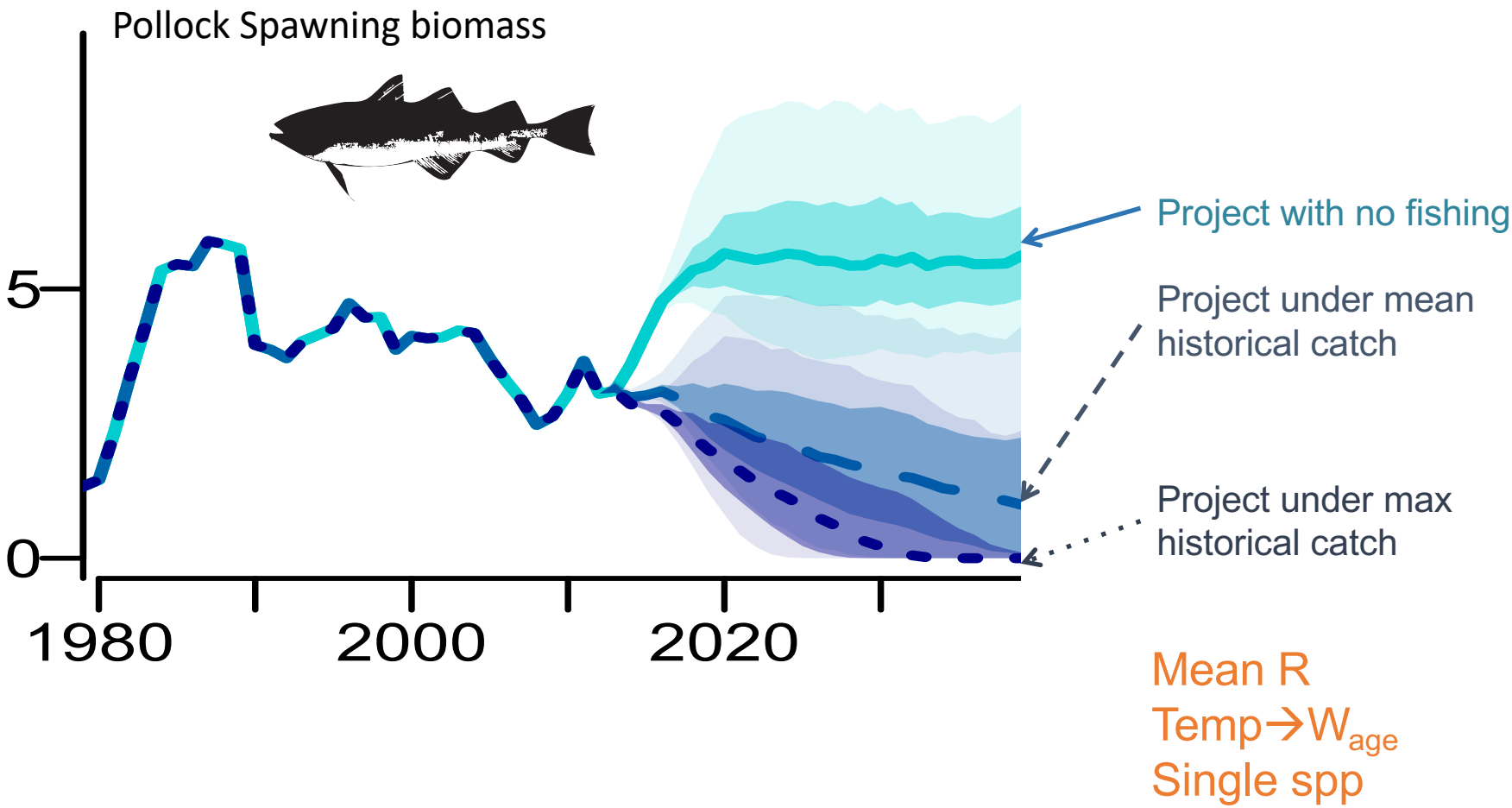
communities of practice
communities of place
upper trophic

Climate-enhanced multispecies model (CEATTLE)

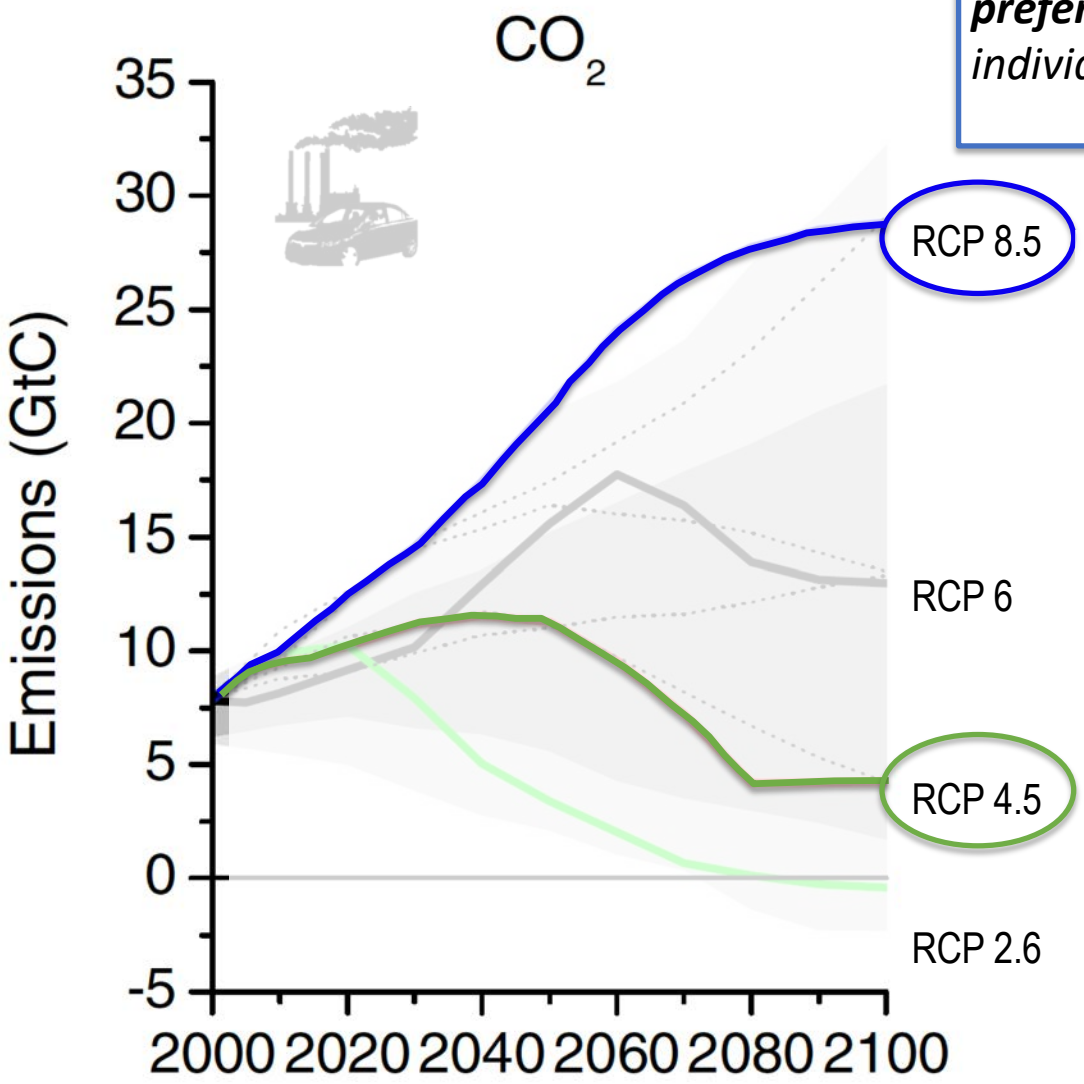


Ianelli, J KK Holsman, AE Punt, K Aydin (2016). Multi-model inference for incorporating trophic and climate uncertainty into stock assessment estimates of fishery biological reference points. Deep Sea Res II. 134: 379-389
DOI: 10.1016/j.dsr2.2015.04.002

Carbon Emission Scenarios

*"**plausible descriptions** of how the future may evolve with respect to a range of variables…they are not meant to be policy prescriptive, (i.e. **no likelihood or preference is attached** to any of the individual scenarios of the set)"*

van Vuuren et al. 2011



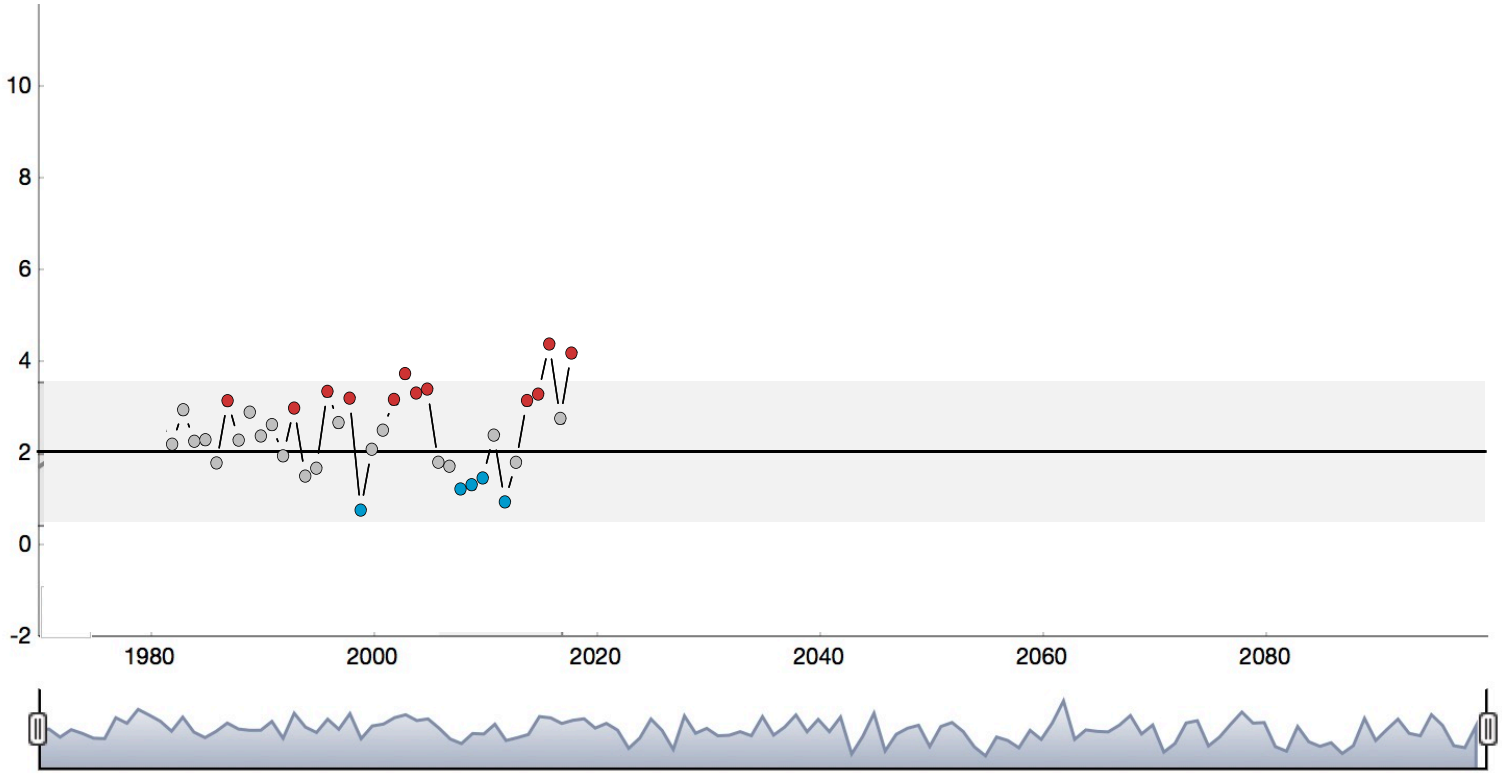
High-Baseline

"Business as usual"

Medium-low

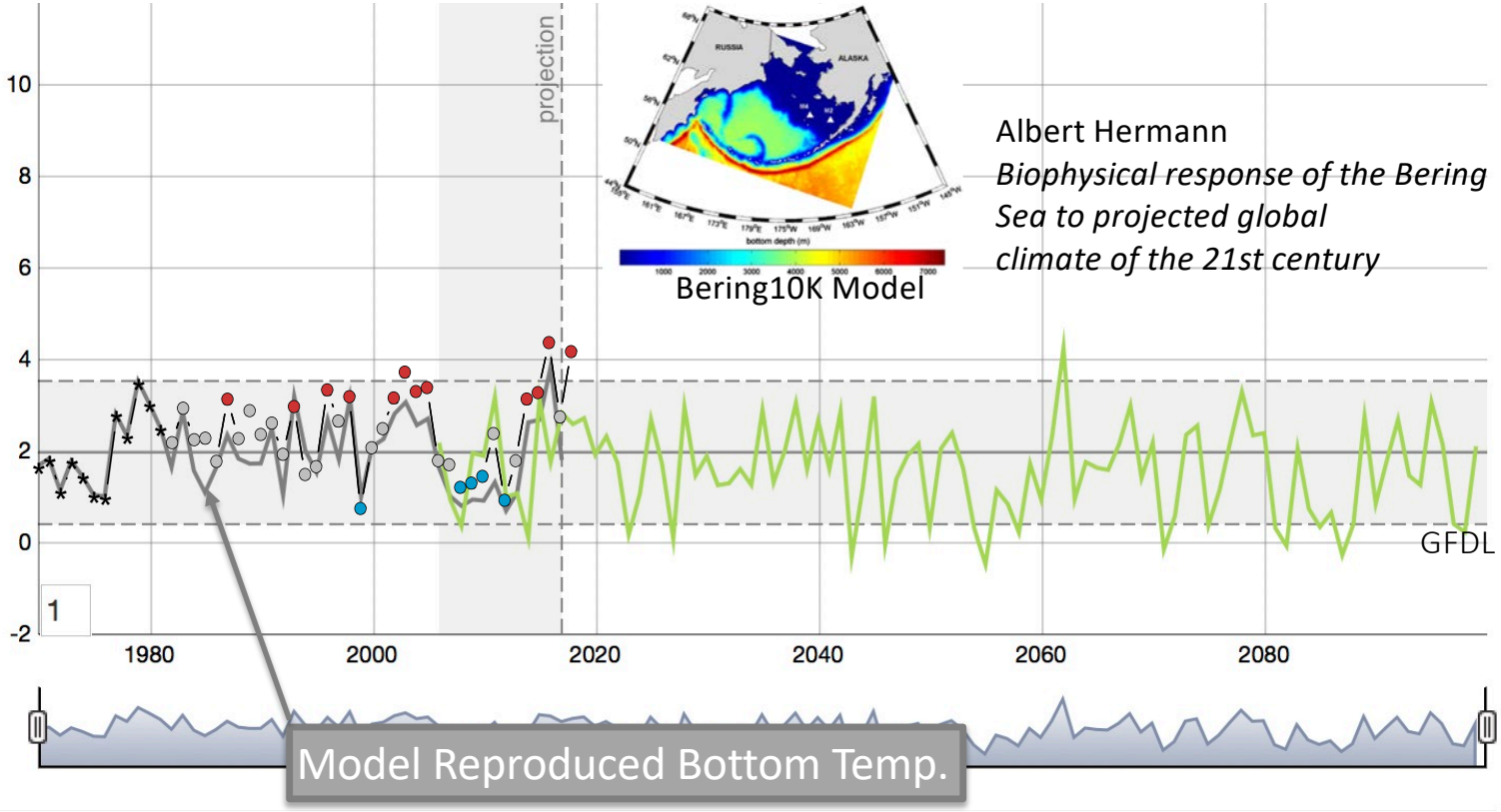
Preliminary Results

Summer Bottom Temperature (°C)



Based on Hermann et al. in review

Summer Bottom Temperature (°C)



Based on Hermann et al. in review

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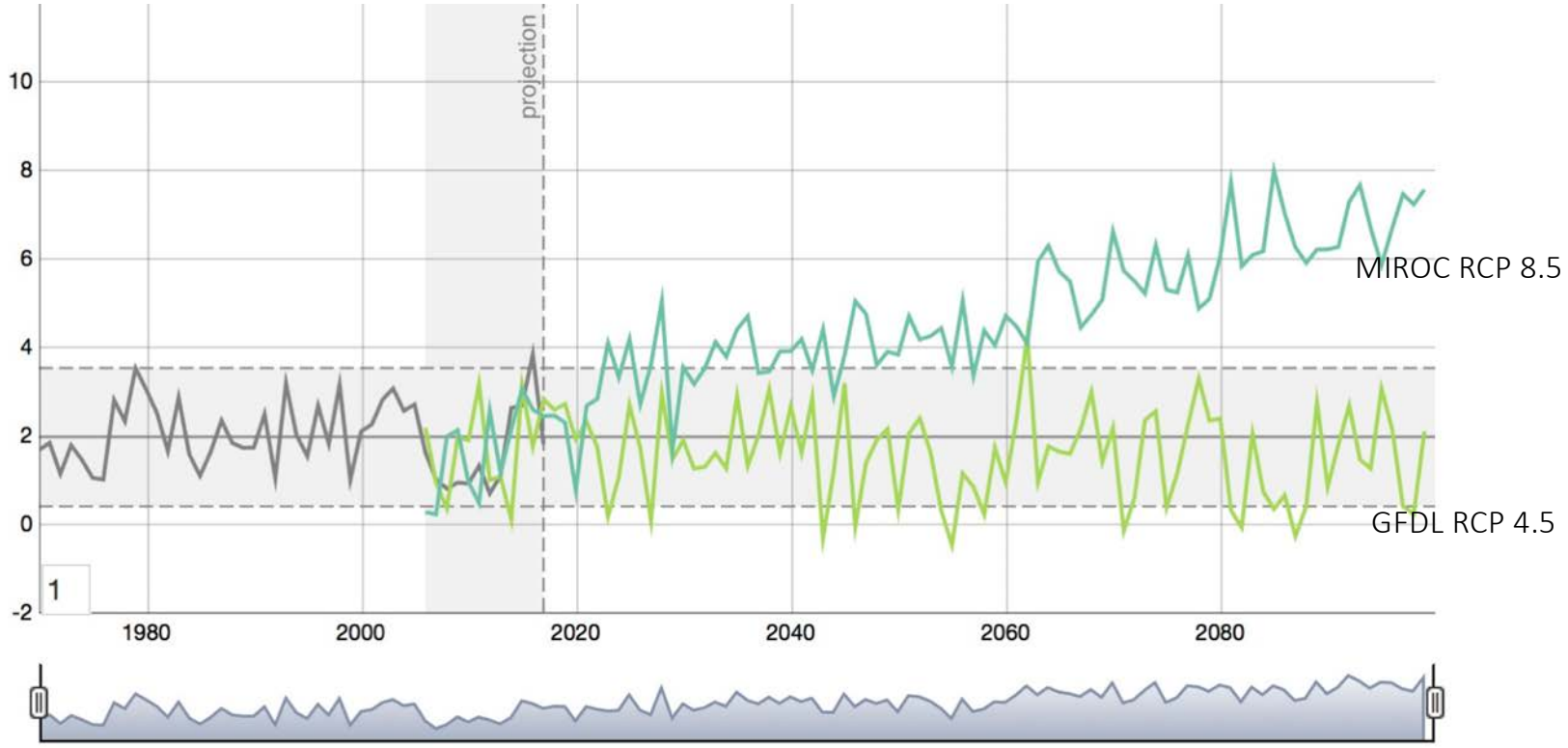

Based on Hermann et al. in review

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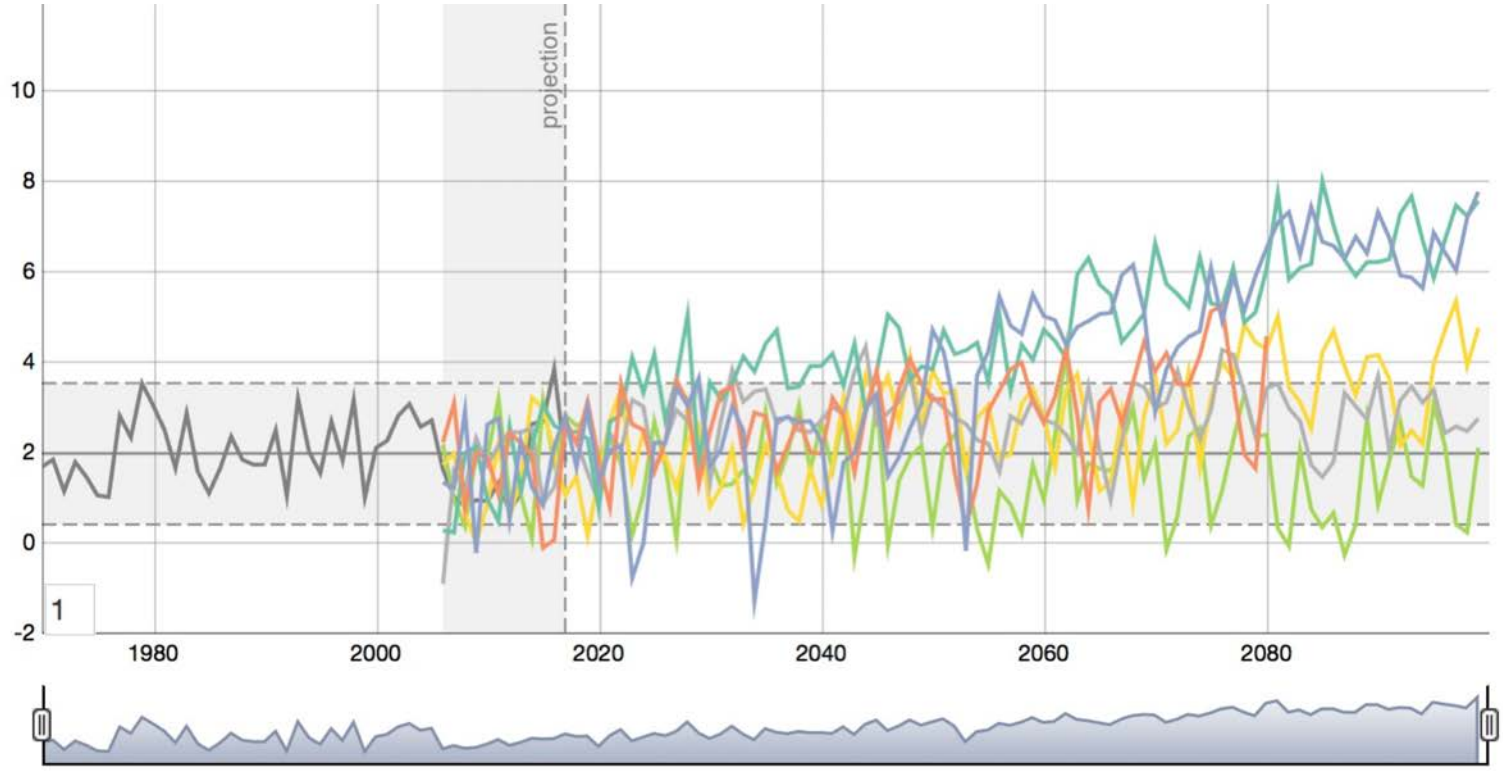
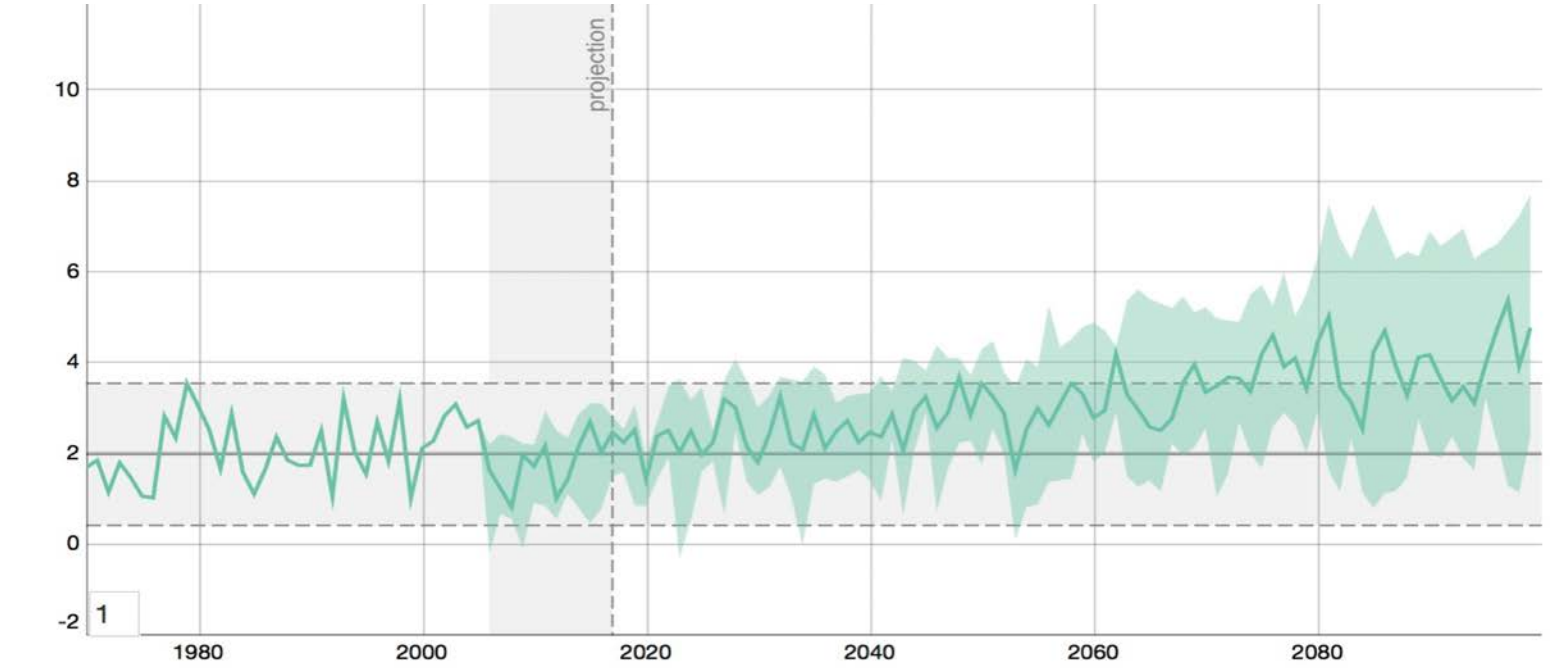


Based on Hermann et al. in review

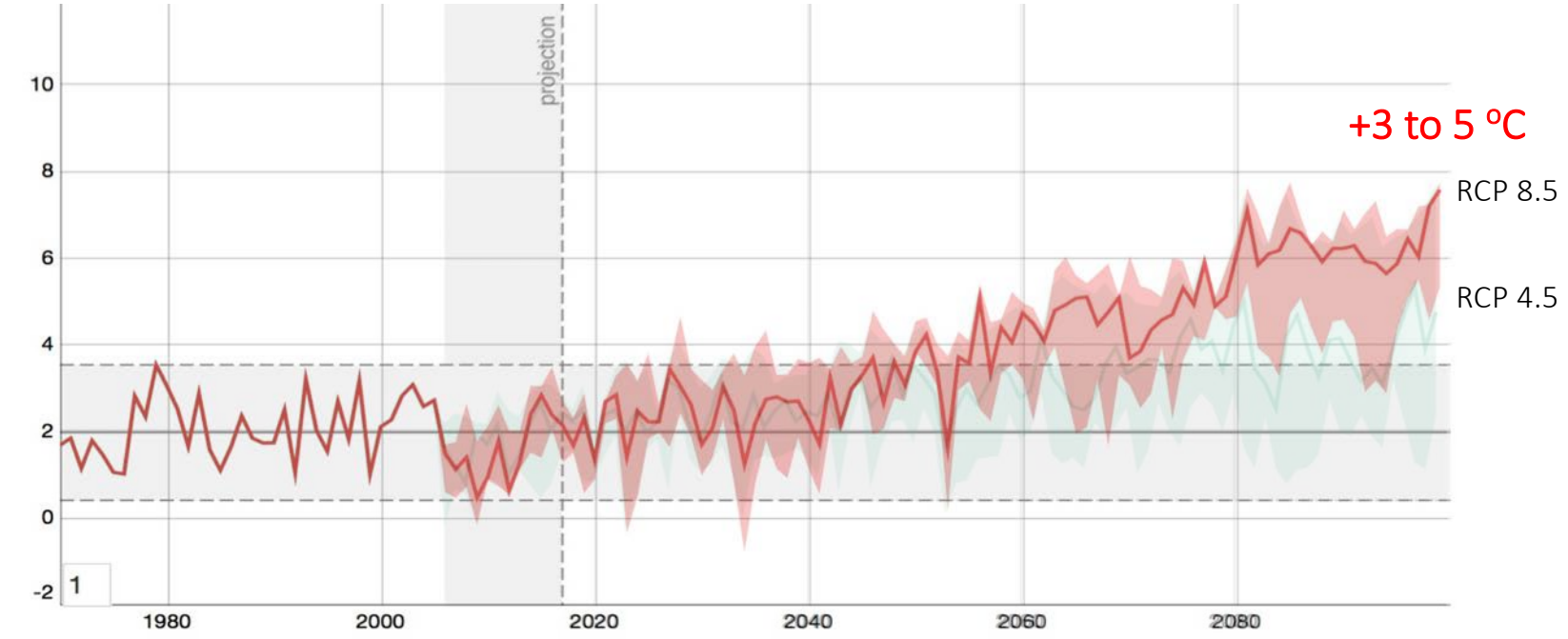
Summer Bottom Temperature (°C)



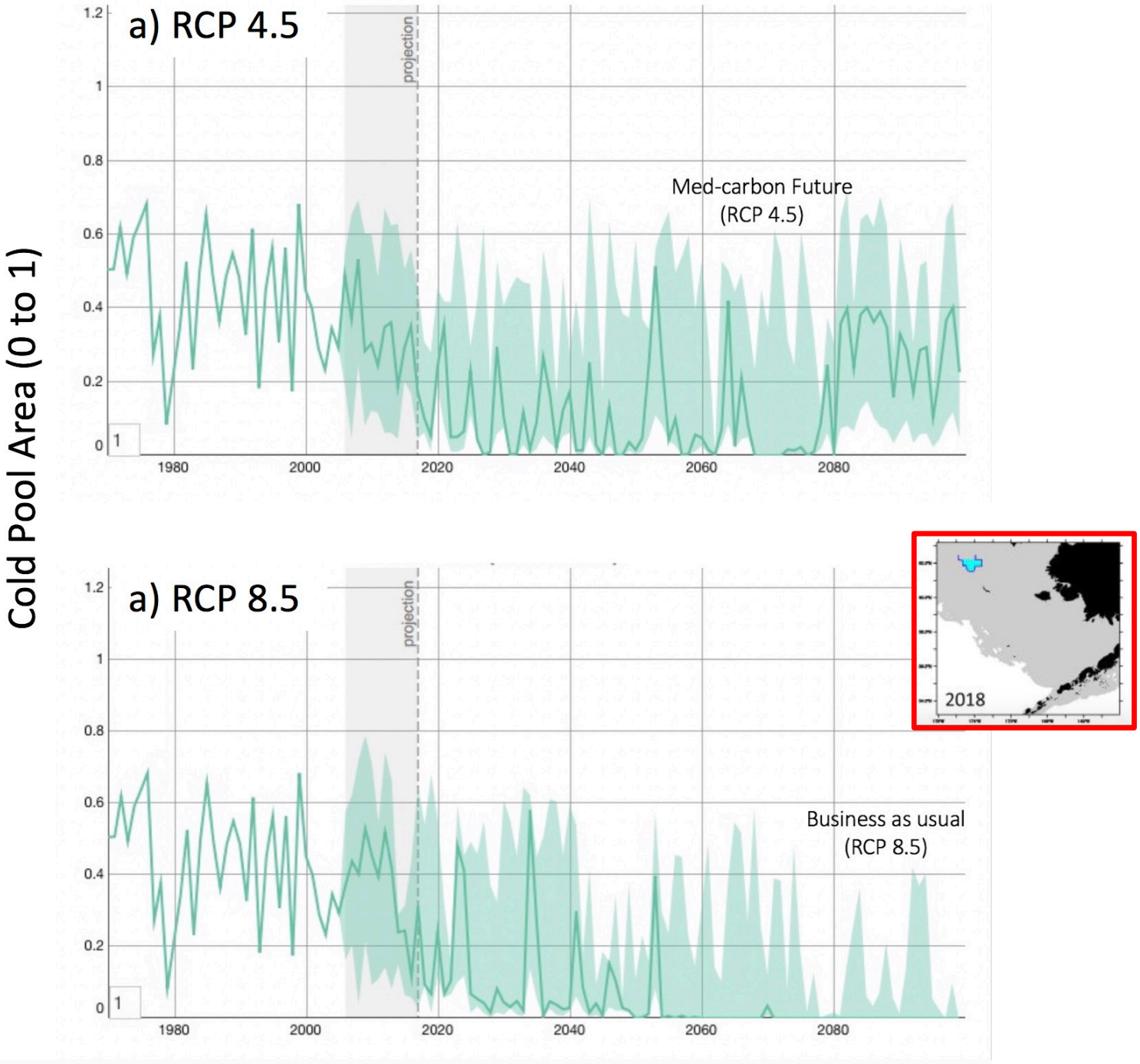
RCP 4.5

Based on Hermann et al. in review

Summer Bottom Temperature (°C)

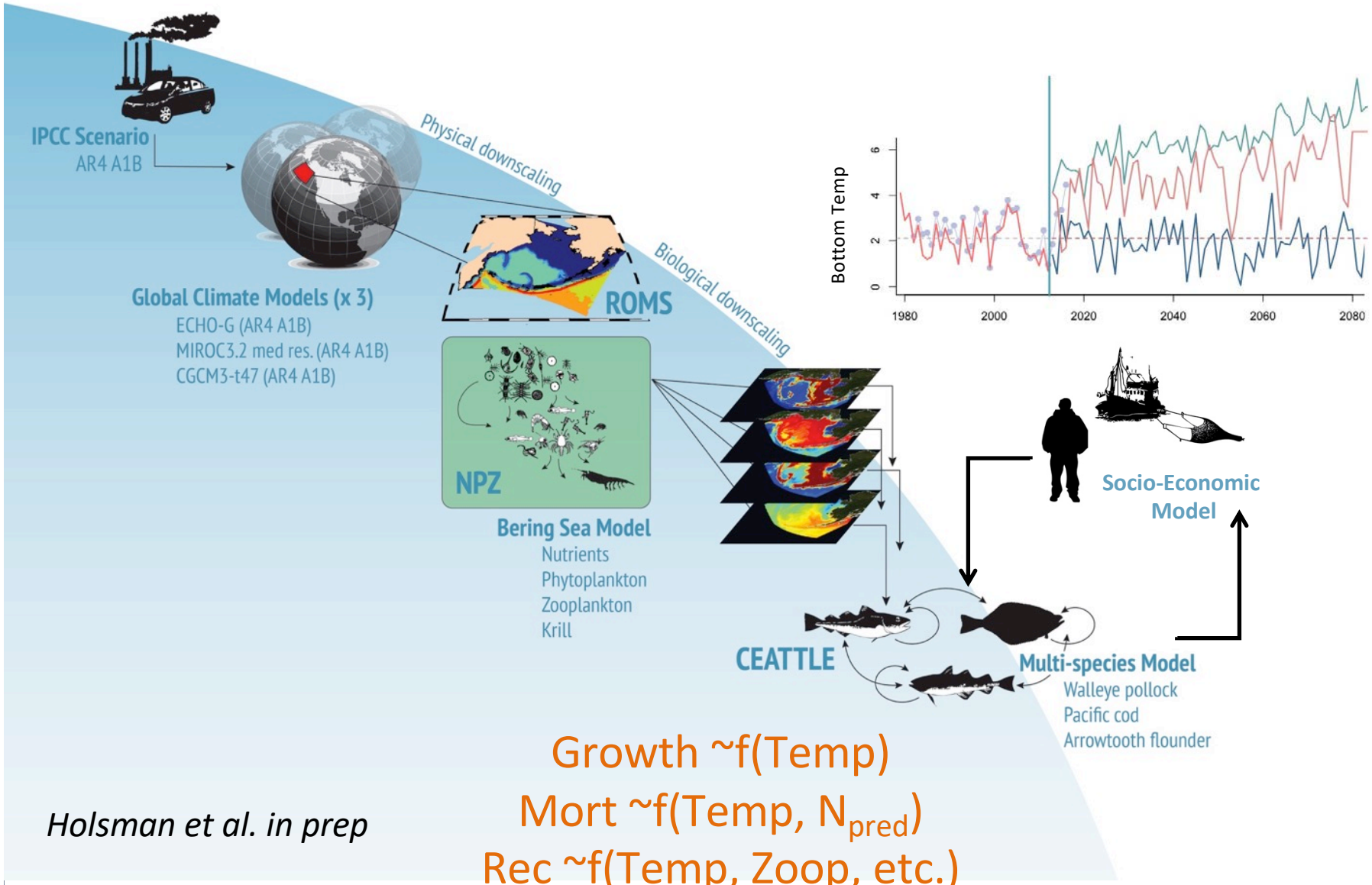


Based on Hermann et al. in review


Cold Pool Area (0 to 1)
a) RCP 4.5
projection
Med-carbon Future
(RCP 4.5)
a) RCP 8.5
projection
Business as usual
(RCP 8.5)
2018
1.2
1
0.8
0.6
0.4
0.2
0
1980
2000
2020
2040
2060
2080

What are the impacts?

Climate-Enhanced Assessment Models

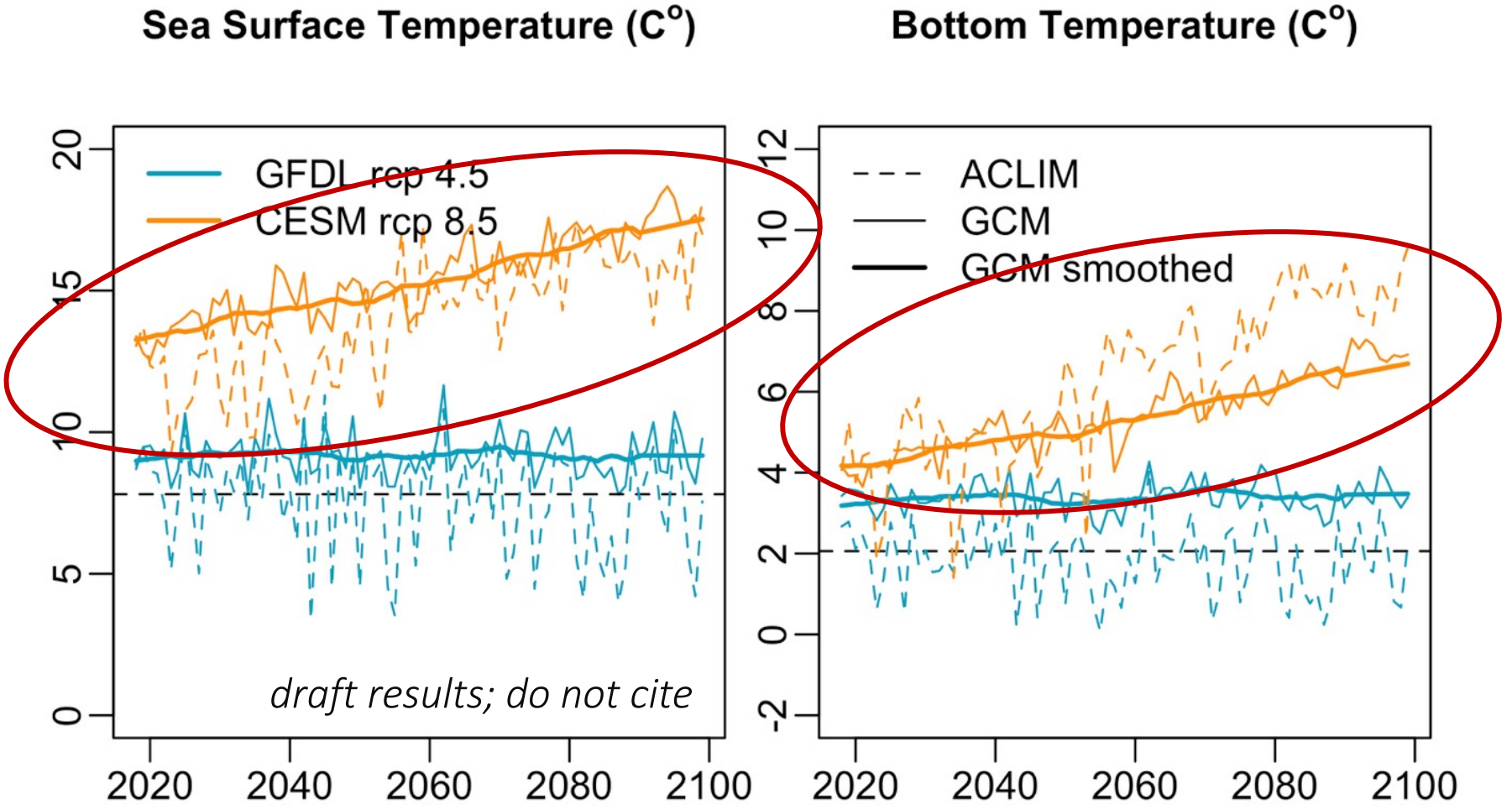


Holsman et al. in prep

Growth ~f(Temp)

Mort ~f(Temp, N_{pred})

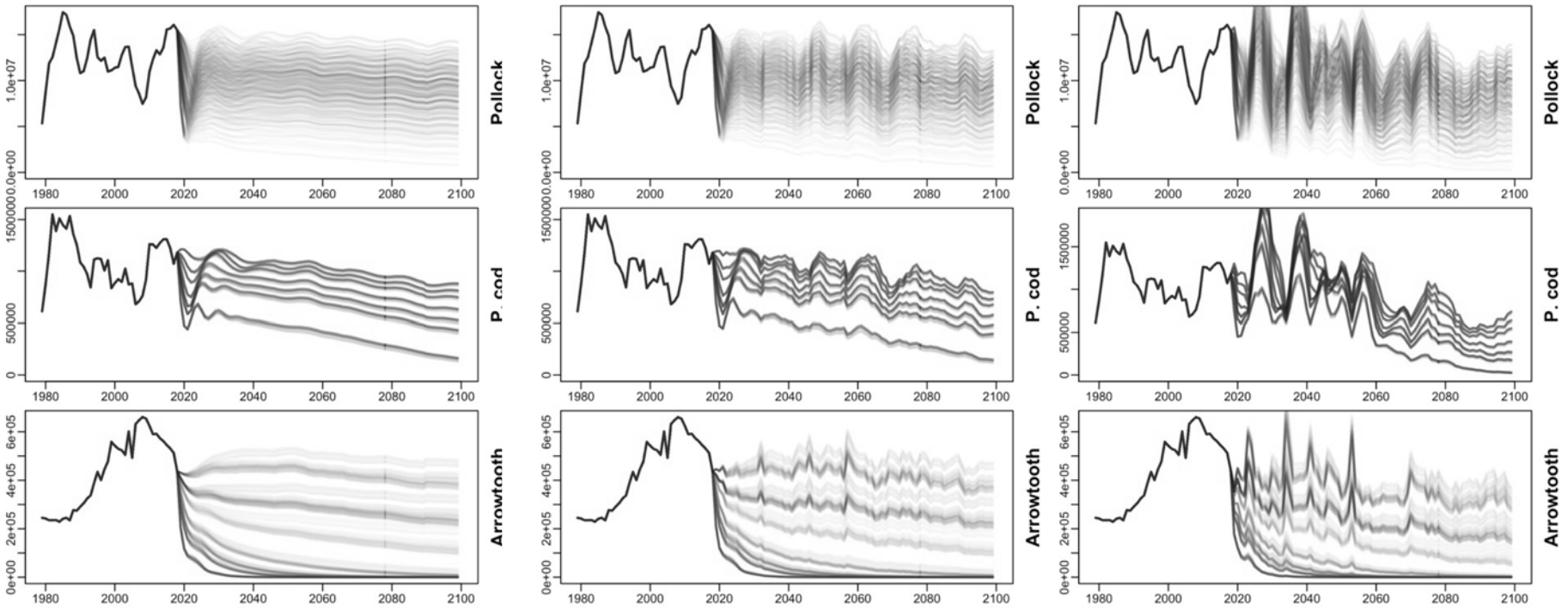
Rec ~f(Temp, Zoop, etc.)


Sea Surface Temperature (C°)
Bottom Temperature (C°)
GFDL rcp 4.5
CESM rcp 8.5
ACLIM
GCM
GCM smoothed
draft results; do not cite
0
5
10
15
20
-2
0
2
4
6
8
10
12
2020
2040
2060
2080
2100

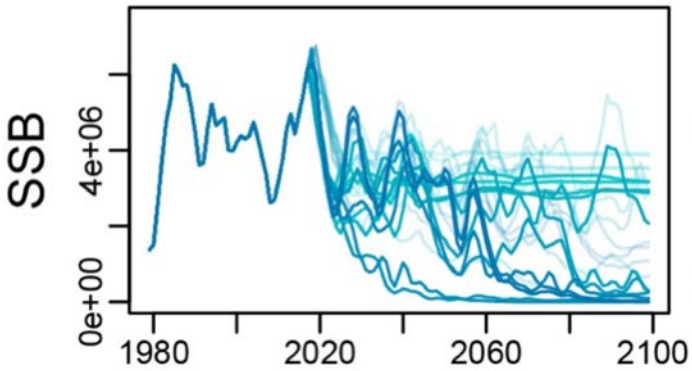
GCM CESM RCP 8.5
(20 yr smooth)

GCM CESM RCP
8.5 (annual)

Downscaled
CESM RCP 8.5



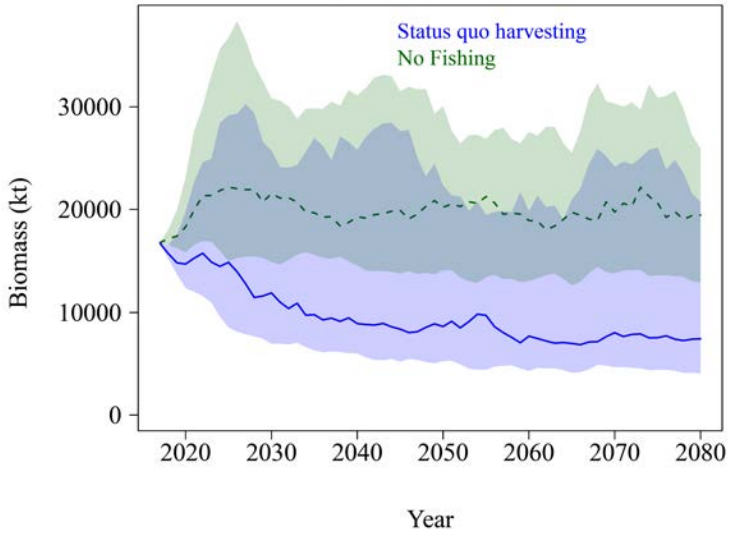
Downscaling is key for understanding variability



CEATTLE model

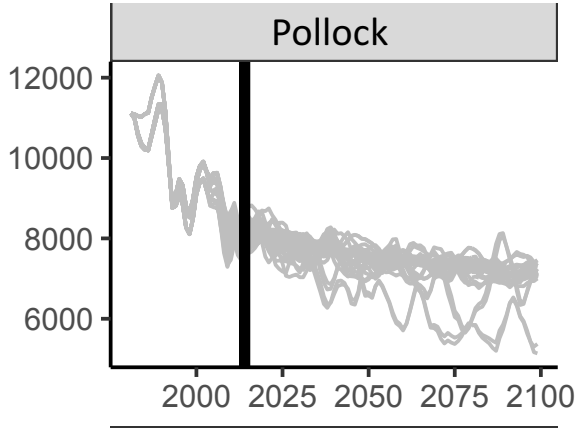
Pollock spawning biomass

Ecologically-enhanced single spp



Spencer et al. in prep

Bering Sea Size-spectrum model



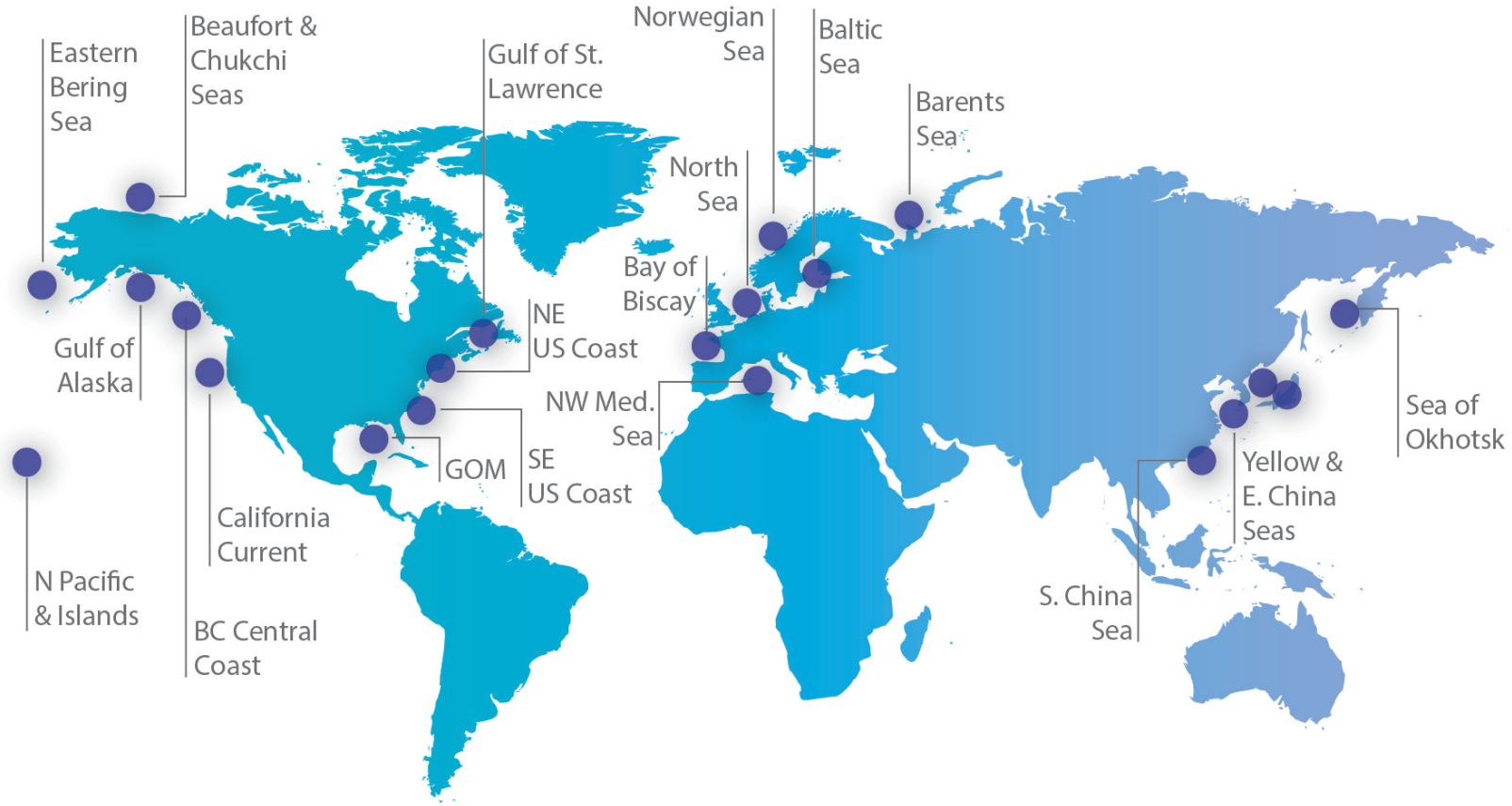
Reum et al. accepted

Synergies are possible despite structural differences

Downscaling is needed	GCMs may underestimate variance in projections
Account for trophic interactions	Accounting for predation changed the direction of projections from increases (single-sp model) to declines (multi-sp)
Mitigation is lower risk	Most pollock and cod scenarios crashed under business as usual (RCP8.5) by 2100; carbon mitigation (RCP 4.5) may lessen or prevent declines
Adaptation through fisheries management	Changing harvest rates through management can help lessen climate impacts, to a point. Considering regional management policies is important.

Holsman et al. in prep

SICCME/S-CCME
Regional Modeling Nodes



ICES-PICES Strategic Initiative on
Climate Change Effects on Marine Ecosystems

Thanks!

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